BRITISH COLUMBIA
ACID MINE DRAINAGE
TASK FORCE

Canada

BC

GEOCHEMICAL ASSESSMENT OF SUBAQUEOUS TAILINGS DISPOSAL IN BUTTLE LAKE, BRITISH COLUMBIA

Rescan Environmental Services Limited
Vancouver, Canada

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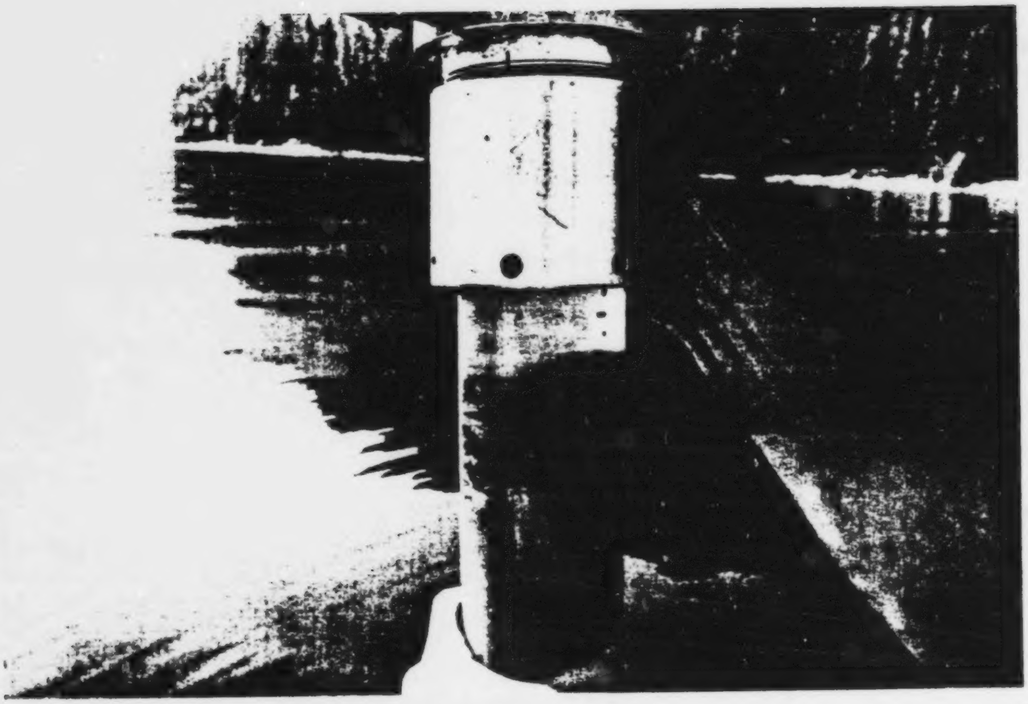

Frontispiece: Photograph of core BUT 2 collected from the south basin of Buttle Lake using the light weight gravity corer described by Pedersen et al (1985). Note the undisturbed interface, clear supernatant water, and natural sediments (brown) overlying grayish tailings.

EXECUTIVE SUMMARY

Limited evidence suggests that the chemical reactivity of tailings is in fact inhibited by storage underwater, and that such storage may be a preferred long-term disposal option. To assess the long-term environmental feasibility of subaqueous disposal of mine tailings, this report examines the waters and sediments of the south basin of Buttle Lake, British Columbia (the site of an inactive submerged tailing deposit). The Cu, Zn and Pb-rich mine tailings were deposited in the lake via a submerged outfall from 1966 to 1984. The tailings are presently areally widespread across the basin and are being covered by a thin veneer of natural sediments. This report presents a detailed study of the distributions of metals in both the solid phases and interstitial waters of the sediments, and in the overlying surface waters.

High resolution profiles of dissolved Zn, Cu, Pb, Cd, Fe and Mn distributions in interstitial waters are presented for four cores collected from the south basin of Buttle Lake in the autumn of 1989. Three of the cores penetrated through the tailings layer into natural (pre-mine) sediments; the fourth, collected near the former tailings discharge point, consisted entirely of relatively coarse-grained pyrite-rich tailings. The dissolved metal distributions are interpreted in concert with mineralogic data and high resolution measurements of major and minor element distributions, including C, N and S, in the associated solid phases.

Water quality sampling was also carried out at the four coring stations. The sampling included physical profiling and discrete water sampling at three depths (surface, mid and bottom) for general parameters and metals analyses. Present water quality sampling and review of past data indicate considerably decreased metal concentrations since metal loadings from Myra Creek were reduced by the implementation of a collection and treatment system in 1983. However, metal concentrations of zinc, copper and cadmium, while decreased, occasionally exceeded provincial objectives proposed for the lake, particularly at depth. Metal concentrations vary seasonally and the highest levels are found during the winter months; concentrations are also higher at depth but apparently not as a result of metal releases from the sediment.

At all coring sites, a 1-2 cm-thick veneer of natural, organic-rich sediments has accumulated on top of the tailings. The distribution of dissolved and solid-phase Fe and

Mn indicates that the sediments are anoxic at all sites within a few cm of the sediment-water interface.

Fe and Mn oxides are enriched in the surface sediments at all locations, but these distributions are not in steady-state equilibrium with the respective pore water profiles. However, both elements are currently being progressively enriched in surface sediments by the diagenetic recycling of Fe and Mn in the upper few cm in all cores.

Dissolved Zn, Cu, Cd and Pb concentrations in pore waters from the former tailings-discharge area are very low in the upper two decimetres. The tailings at this location accumulated very rapidly, and the pore water results and benthic influx calculations indicate that there is currently no flux of Zn, Cu, Cd or Pb to the overlying water column at this site. In pore waters from the other locations, all of which are characterized by a layer of tailings up to three decimetres thick sitting atop methane-bearing anoxic natural sediments, dissolved Cu, Pb and Cd occur in relatively low concentration in the upper few centimetres. Zn concentrations in the pore waters at shallow depths are slightly higher than in bottom water of the lake at all three sites, suggesting that there is an upward flux of the metal to the overlying water. However, the precipitation of Fe oxyhydroxides in the upper 30 to 50 mm at these locations appears to reduce the efflux of dissolved metals. Dissolved Zn, Cu, Pb and Cd are enriched together in specific, thin subsurface zones in all cores, indicating limited zones of release at depth. Such zones correlate with the presence of high dissolved organic carbon contents.

Benthic flux calculations indicate that effluxes of Zn, Cu, Cd and Pb from the sediments are very low, and are comparable in magnitude to fluxes associated with natural geochemical processes in lakes and coastal marine sediments. A conservative (worst case) estimation suggests that less than 0.2 parts per trillion of Zn are being added to south basin deep water as a result of chemical reactivity of the metal-rich deposits on the lake floor. This amount is negligible, and it is reasonable to conclude that the submerged tailings are having no impact on Buttle Lake water quality at the present time. As burial by natural sediments continues, this conclusion will be reinforced.

ACKNOWLEDGEMENTS

A number of people have made substantive contributions to this project. Clem Pelletier of Rescan Environmental Services Ltd. (Rescan) provided overall project coordination and senior review of the report. Dr. Tom Pedersen of the University of British Columbia (UBC) was responsible for detailed sediment work including sampling, analysis and reporting of this work. Bill Duncan (Rescan) was responsible for water quality sampling, data compilation and reporting of this work.

Rescan personnel involved in various aspects of the project, included Paul Davidson who assisted with water quality sampling, Monica Macierwicz who meticulously entered and validated the water quality and climate data into the database, and Janice Kukurudz who patiently wordprocessed this document. Review and editorial comments were provided by Gary Birch and David Flather. Water quality analyses were performed by Analytical Services Laboratory Ltd.

UBC personnel included Jay McNee and Patrick O'Hara who were instrumental in helping collect quality cores, and both carefully assisted with extraction and filtration of the interstitial water samples in the laboratory at the Westmin minesite. Bert Mueller performed the dissolved metals analyses with great care in the laboratory at UBC, and Maureen Soon, Shirley French, and Mark Noyon provided assistance and analytical expertise in making XRF, carbon, nitrogen, and sulphur measurements, also at UBC. Lowell Wade expeditiously provided X-ray diffraction data.

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1 - Introduction

1.0 INTRODUCTION

Disposal of sulphide-bearing mine tailings to marine and lacustrine waters has been practiced for millennia, often without consideration of the potential long-term reactivity of such metal-rich phases. Limited evidence is now available which suggests that chemical reactivity of submerged tailings is in fact inhibited by storage underwater, as summarized in the recent report to the Acid Mine Drainage Task Force (Rescan, 1989). However, very few assessments have been carried out in which the post-depositional (diagenetic) chemical character and behaviour of inactive submerged tailings deposits have been studied in detail. Extant information describes the chemical behaviour of tailings on the sea floor or lake bottoms during periods of active deposition (e.g. Pedersen, 1983a, 1984, 1985, and Pedersen and Losher, 1988); no detailed descriptions of the longer-term reactivity of inactive or abandoned submerged deposits have been published.

This rather sparse database constrains environmental impact planning and limits both regulatory and disposal options. Thus, there is a well-defined need for quality information on the long-term diagenetic reactivity of submerged mine wastes, both in marine and lacustrine waters. In this report, we present the results of the first detailed study of the distributions of metals in both the solid phases and interstitial waters of the abandoned tailings deposit in Buttle Lake, British Columbia, which is now being covered by a veneer of natural sediments.

1.1 Background to Study

In 1966, Westmin Resources commenced operation of a Zn-Cu-Pb-Au massive sulphide mine in Strathcona Park, Vancouver Island, B.C. The mine is located adjacent to Myra Creek and 6 km west of the south basin of Buttle Lake (Figure 1-1). The south basin is about 7 km long, and reaches a maximum depth of 87 m, roughly 4 km north of the former tailings discharge point (Figure 1-1). Some 5.5 x 10^6 tons of tailings were discharged to this basin via a submerged outfall between 1966 and July, 1984, when the disposal strategy switched to tailing ponds on land. A relatively shallow sill about 5 km north of the outfall effectively confined physical dispersion to the south basin.

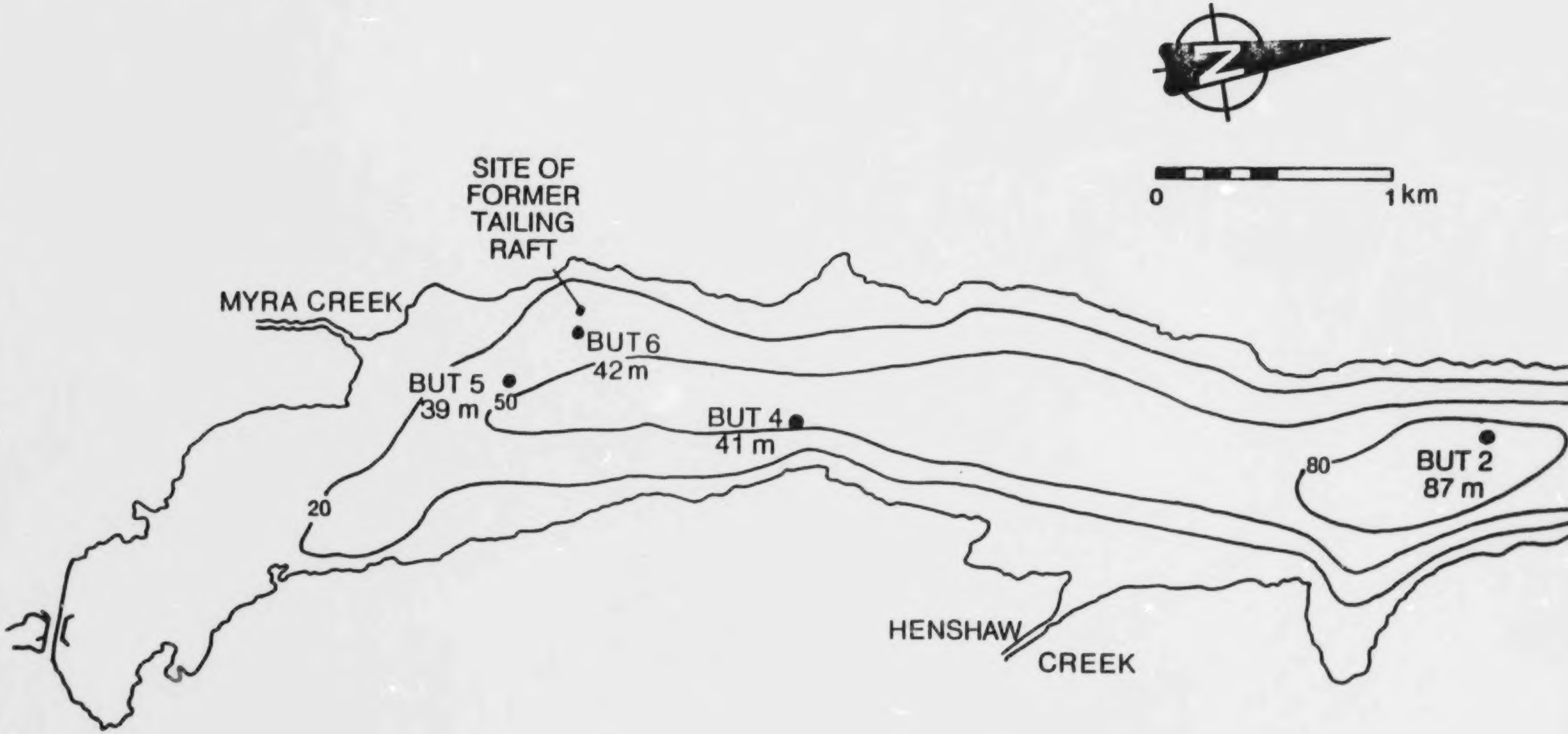

Figure 1-1 Core locations, south basin of Buttle Lake, Autumn, 1989. Isobaths (in metres) from Bohn (1982).

Westmin's current and past operations in the Myra Creek valley (summarized by Rescan, 1989) include the H-W, Lynx, Myra and Price mines from which Cu, Pb, Zn, Au, Ag, and Cd have been recovered. Open pit and underground mining of the Lynx deposit began in 1966 with a mill capacity of 750 tpd. Mill capacity has been increased several times; current output is about 4400 tpd. The mill process uses conventional crushing and grinding followed by differential flotation to produce separate copper, lead and zinc concentrates.

After concentrator startup in late 1966, tailings were discharged to a small nearby pond. Direct discharge to the lake commenced shortly thereafter. The sand-sized material from the tailings underflow was removed by cycloning and used as backfill in the underground mine, while the cyclone slime overflow was conducted from the minesite down a pipeline through seven drop boxes to a raft about 100 m offshore. The tails were discharged below the thermocline via a submerged outfall. Flocculants were used to assist settling of the solids.

The tailings were originally derived from the zinc circuit after milling of the high grade Cu-Pb-Zn ore and consisted of sand-sized and silt-sized silicate gangue minerals and residual copper, iron, lead and zinc sulphides. Base metal concentrations in the tailings solids ranged widely but averaged 7000, 1300 and 900 mg/kg for Zn, Cu and Pb, respectively. Lime (CaO) was the only reagent used in significant quantity; approximately 1.0 kg per tonne of ore was added to the tailings to raise the pH in the milling circuits and to enhance coagulation in the thickening tanks (Eccles, 1977). During the initial six years of operation, with ore from the Lynx Mine, dissolution of heavy metals in the milling circuit was minimal due to the high pH and extremely low solubility of metal sulphides. In June of 1970, the mill began limited production of lead ore (galena) and in early 1973 this was increased when high-lead ore came on-line. Because production of a copper concentrate with a low lead content was required, cyanide was used in the continuous copper-lead separation circuit. This resulted in substantially increased levels of cyanide and dissolved Cu in the effluent (at high pH, Cu complexes with CN^-). Consequently Westmin introduced alkaline chlorination to destroy residual cyanide and to precipitate dissolved Cu in the tailings. Metal concentrations in the effluent stream fell substantially after this introduction (see Table 5-8 in Rescan, 1989).

Dissolved zinc, copper, lead and cadmium concentrations in Buttle Lake water began to increase shortly after the mine commenced operation and peaked in 1981, reaching levels in south basin surface waters as high as 5.7 μmol L^{-1} (370 μg L^{-1}) Zn, 0.6 μmol L^{-1} (40 μg L^{-1}) Cu, 0.12 μmol L^{-1} (25 μg L^{-1}) Pb, and 32 μmol L^{-1} (3.6 μg L^{-1}) Cd (Deniseger et al., 1988). The high metal loadings were derived from acid mine drainage which percolated from a waste rock area into Myra Creek and thence to the lake. A report prepared for the mine in 1982 (Pedersen, 1982) and published a year later (Pedersen, 1983a) indicated that the tailings on the lake floor were not releasing dissolved metals into the overlying water column during the period when the lake water was badly contaminated. In 1983, a surface and groundwater collection and treatment system was installed to capture the bulk of the acid drainage. Metal levels subsequently declined significantly, although they have not yet reached historical background levels (L. Erickson, Waste Management Branch, Nanaimo, B.C., pers. comm.). Deniseger et al. (1988) note for example that Zn concentrations at depth frequently exceed the objective of 0.8 μmol L^{-1} (50 μg L^{-1}). The high levels are attributed to continuing addition to the lake of metal-rich water derived from the mine site and delivered via Myra Creek. The most recent data (L. Ericksen, pers. comm.) show that for the last seven months of 1989 at the deepest station sampled (60 m depth off Henshaw Creek, Figure 1-1), the concentration of Zn ranged from 0.6 to 0.9 μmol L^{-1} (40-60 μg g^{-1}), Cu from 0.02 to 0.08 μmol L^{-1} (1-5 μg g^{-1}), and Pb from 0.005 to 0.01 μmol L^{-1} (<1-2 μg g^{-1}); Cd concentrations were always <4 nmol L^{-1} (<0.5 μg g^{-1}).

A second potential metal source remains the tailings. Pedersen (1982) suggested that oxidative diagenesis of the tailings might be expected to occur for a period immediately after the cessation of discharge, prior to the deposits being covered with a veneer of organic-rich natural sediments. Such a stratum would eventually be expected to foster anoxia at some (presumably shallow) depth, thus inhibiting potential further release of metals. Pedersen (1983b) used measured ^{210}Pb and Mn distributions in a suite of cores collected from the south basin in July 1983 to estimate that 7 to 15 years would elapse before the tailings were covered by a layer of natural sediments thick enough to prevent oxidation. This estimate was reevaluated in this report.

2 - Study Area and Methods

2.0 STUDY AREA AND METHODS

2.1 Study Area

Buttle Lake is a large (35 km long x 1 km wide x 45 m deep) water body which occupies a U-shaped valley in an area of high relief on central Vancouver Island (Figure 1-1). Like many lakes on Vancouver Island, Buttle Lake is oligotrophic; nutrient levels are relatively low (Deniseger et al., 1988). The lake drains northeastward into Georgia Strait via Campbell lakes and the Campbell River, a major spawning watercourse for salmon.

2.2 Sampling Stations

Four primary sampling stations (BUT 2, 4, 5 and 6) were located throughout the south basin of Buttle Lake (Figure 1-1), but were concentrated near the site of former tailings discharge point. Water quality sampling, CTD profiling and lake sediment coring for pore water and solids analyses were conducted at each sampling station.

2.3 Study Methods

2.3.1 Water Quality, Hydrology and Climate Data Compilations

Buttle Lake and Myra Creek have been extensively studied and numerous reports have been found in the literature and libraries of Westmin Resources Ltd., B.C. Research Ltd. and B.C. Ministry of Environment, Waste Management Branch, Nanaimo, B.C. The Waste Management Branch (WMB) has sampled numerous water quality sites in the Buttle-Campbell-John Hart Lake system. Monitoring first began in 1966, with regular monthly monitoring beginning in 1980, subsequently reduced to bimonthly monitoring in 1988. Due to the large size of the data set, only selected sites and only a limited parameter set were included in the dBASE computer storage and retrieval system. The two sites included are WMB stations 0130082 (Buttle Lake off Henshaw Creek) and 0130080 (Buttle Lake at Gold River Bridge). The parameter set included pH, temperature, specific conductivity, dissolved oxygen, extinction depth, total metals (Ca, Cd, Cu, Fe, Mg, Mn, Pb and Zn) and dissolved metals (Cd, Cu, Fe, Mn, Pb and Zn).

Available hydrological data from reports produced for Westmin Resources Ltd. have been obtained and supplemented by data available from B.C. Hydro. Climatological data were obtained from Westmin Resources Ltd. for the Myra Creek Station and from Environment Canada, Atmospheric Environment Services and entered into a dBASE file. Data included monthly precipitation and temperature values.

2.3.2 Water Quality

Lake water samples were collected at the four primary stations (Figure 1-1) using a Teflon-lined 5 L Go-Flow water sampler. Samples were taken at three depths where possible (0.5 m below the surface, mid-depth and at the bottom). The 1 L polyethylene sample bottles and caps were rinsed with sample water prior to filling. Bottles were carefully filled to the top using a Teflon tube attached to the water sampler to minimize air contact. No preservatives were added to the 1 L bottles which were maintained at 4°C during shipping and handling. The 250 ml acid-washed polyethylene bottles were filled in the same manner, field filtered and 2 ml nitric acid added for dissolved metal analysis.

Water samples were analyzed by Analytical Services Laboratories Ltd. (ASL) of Vancouver, B.C. Samples were analyzed for physical parameters including pH, specific conductivity, turbidity (NTU), total dissolved solids and total suspended solids (volatile and fixed), as well as anions and nutrients including alkalinity, sulphate, chloride, reactive silica, total phosphorus, nitrate/nitrite, ammonia, total dissolved nitrogen and total organic carbon using standard methods (APHA, 1985).

Dissolved metals were analyzed by various atomic absorption and emission spectroscopy methods as follows:

- Inductively coupled argon plasma (ICP) emission spectroscopy for higher concentration elements
- Graphite furnace atomic absorption spectroscopy for low concentration element
- Hydride generation atomic absorption spectroscopy for arsenic
- Cold vapour atomic absorption spectroscopy for mercury

In addition to water quality sampling, measurements were also made in the water column at the four stations where coring for pore water chemistry was performed. An Applied Microsystems CTD 12 profiler was used to measure conductivity, temperature, dissolved oxygen, pH, depth and transmissibility. The CTD 12 profiler was calibrated then lowered at each of the four stations at a speed of 0.5 - 1 m s^{-1}. The instrument sampling interval was programmed to read every 10 cm through the water column. Data were stored in the instrument and was downloaded at the surface to a microcomputer.

2.3.3 Core Collection and Processing

Four cores were collected from the south basin of Buttle Lake during the period of September 29 - October 1, 1989 using the lightweight gravity corer described by Pedersen et al. (1985), and either hydraulic or gas-powered winches mounted on an aluminum workboat. The corer uses an open catcher-free cleaned butyrate barrel, and is designed to minimize disturbance of the sediment-water interface during core collection. A very slow entry speed (about 10 cm s^{-1}) was used at all sites. An excellent interface (Frontispiece) was recovered at two of the four sites (BUT 2 and 4; Figure 1-1), where the corer penetrated through tailings into the underlying (pre-mine) natural sediments. Slight doming of the upper cm was observed at BUT 5; an estimated 5 mm of flocculent material was lost from the edges of the core at this location. The relatively coarse tailings at BUT 6 were essentially cohesionless and repeatedly washed out of the core barrel during several coring attempts. Hence, at this site alone, a soft plastic sphincter-type core catcher was fashioned on the spot and taped to the base of the open barrel. This permitted recovery of Core BUT 6, but at the cost of minor disturbance of the core top. As the data will attest, such disturbance had no significant effect on the quality of the analytical results obtained from this site. Cores were sealed with a full column of supernatant water immediately after removal from the corer, logged, and transported hand-held back to the mine site to minimize disturbance. Detailed core logs are listed in Appendix A.

Interstitial water samples were extracted from the cores in an environmental chemistry laboratory at the mine. To avoid oxidation artifacts during sampling (e.g. Bray et al., 1973), each core was extruded directly into a nitrogen-filled glove bag by gradually jacking up an o-ring sealed piston inside the barrel. The supernatant water on the top of the core was carefully removed by siphoning prior to extrusion, with the exception of the lower 10 cm of water which was removed with a syringe once the core was secured in the nitrogen atmosphere. A sample of this core-top water was collected for each core and was subsequently analyzed as "supernatant" water. In each case, processing commenced within two hours of collection of the core. Samples were sequentially sliced from the core, placed into 250 ml N_2-filled centrifuge bottles, sealed, removed from the glove bag, and centrifuged for 20 minutes at approximately 1200 RCF (Relative Centrifugal Force). The bottles were then placed in another N_2-filled glove bag, the supernatant water in each was decanted into a polypropylene syringe barrel, and the water was expressed through Nuclepore™ 0.45 μm polycarbonate membrane filters into 30 ml sample bottles. Five to 20 ml were typically recovered, the smallest volumes corresponding to the thin sample intervals used near the top of each core. Ultrapure Seastar™ concentrated HNO_3 was added immediately to the samples in proportion to their volume to bring the pH to 2. All plasticware and filters were rigorously acid-washed in a Class 100 laminar flow bench as follows. Virgin plasticware (except pipette tips) was:

1. wiped outside and rinsed inside with reagent grade chloroform to remove grease and soluble organic residues;
2. soaked at least 1 day in hot (40°C) 20% reagent-grade HNO_3;
3. rinsed twice with DDW (distilled, deionized water);
4. soaked at least 1 day in 0.1% Seastar ultrapure HNO_3;
5. rinsed once in DDW;
6. soaked at least 1 day in 0.1% Seastar HNO_3;
7. rinsed once in DDW; and
8. dried covered in a drying oven.

In order to obtain high resolution profiles to define diagenetic reactivity in the upper few centimeters of the sediments, 5 mm sample intervals were used in cores BUT 2, 4 and 6 for the top two cm, one cm increments were used for the next several cm, and 2 cm-thick slices were selected at intervals below the upper decimetre. One cm thick increments were selected for the upper portion of the core BUT 5 because the top was downbowed slightly during the coring and it was felt that 5 mm-thick samples would not yield enough water for subsequent analysis. Approximately 16 samples were collected from each core.

All samples were returned to UBC for analysis. The sediment samples were frozen and freeze-dried. An aliquot of each was ground in a tungsten carbide disk mill prior to preparation for X-ray fluorescence, CNS, and mineralogical analysis (XRD). Detailed analytical methods and quality control procedures are described in Appendix B.

3 - Results

3.0 RESULTS

3.1 Water Quality

Water column profiles of temperature, conductivity and percent transmission at the four stations in the south basin of Buttle Lake indicated the same general pattern at each station (Figures 3-1, 3-2, 3-3 and 3-4). Conductivity was low and varied little with depth. Percent transmission, while generally greater than 80%, was slightly lower in the surface 10 m and decreased again within 0.5 m of the bottom at stations BUT 5 and BUT 6. Temperature profiles indicated surface warming was occurring with surface temperatures near 7.5 °C decreasing uniformly to less than 5.0 °C at 40 m depth and to a minimum of 4.2 °C at 85 m depth. A strong thermocline had not yet developed in the south basin in late April, 1990.

Results of water quality testing at the four stations indicated generally similar water quality at each of the stations and to some extent depths sampled (Appendix C). The lake is soft with a calculated hardness (Ca, Mg) ranging from approximately 30 to 40 mg L^{-1} as $CaCO_3$. Calcium and magnesium concentrations range from 11.4 to 14.5 mg L^{-1} and 0.68 to 1.10 mg L^{-1}, respectively. The lake is nearly neutral in pH (approx. 7.1), with alkalinity of approximately 23 mg L^{-1} as $CaCO_3$. Sulphate concentrations were low ranging from 8.7 to 16.7 mg L^{-1} with the lowest concentrations found at the surface. Chloride concentrations were generally less than 0.5 mg L^{-1}.

Conductivity varied slightly from 70.5 to 95.6 μmhos cm^{-1} and generally increased with depth at each site; dissolved solids showed a similar pattern ranging from 50 to 80 mg L^{-1}. Suspended, fixed and volatile solids concentrations were low (<5 mg L^{-1}) as was turbidity (generally <0.5 NTU). Concentrations of nutrients were low and varied little between stations. Total phosphorus concentrations ranged from 0.001 to 0.004 mg L^{-1}, while nitrate-nitrite nitrogen concentrations ranged from 0.064 to 0.13 mg L^{-1} with the lowest values found at the surface. Total organic carbon concentrations were low ranging from 0.80 to 1.05 mg L^{-1} and reactive silicate ranged from 3.6 to 4.7 mg L^{-1}. Neither of these parameters showed any consistent variation with depth.

Dissolved metal concentrations of aluminum, arsenic, copper, manganese and zinc were consistently above detection limits. Most metal levels were highest near the bottom at

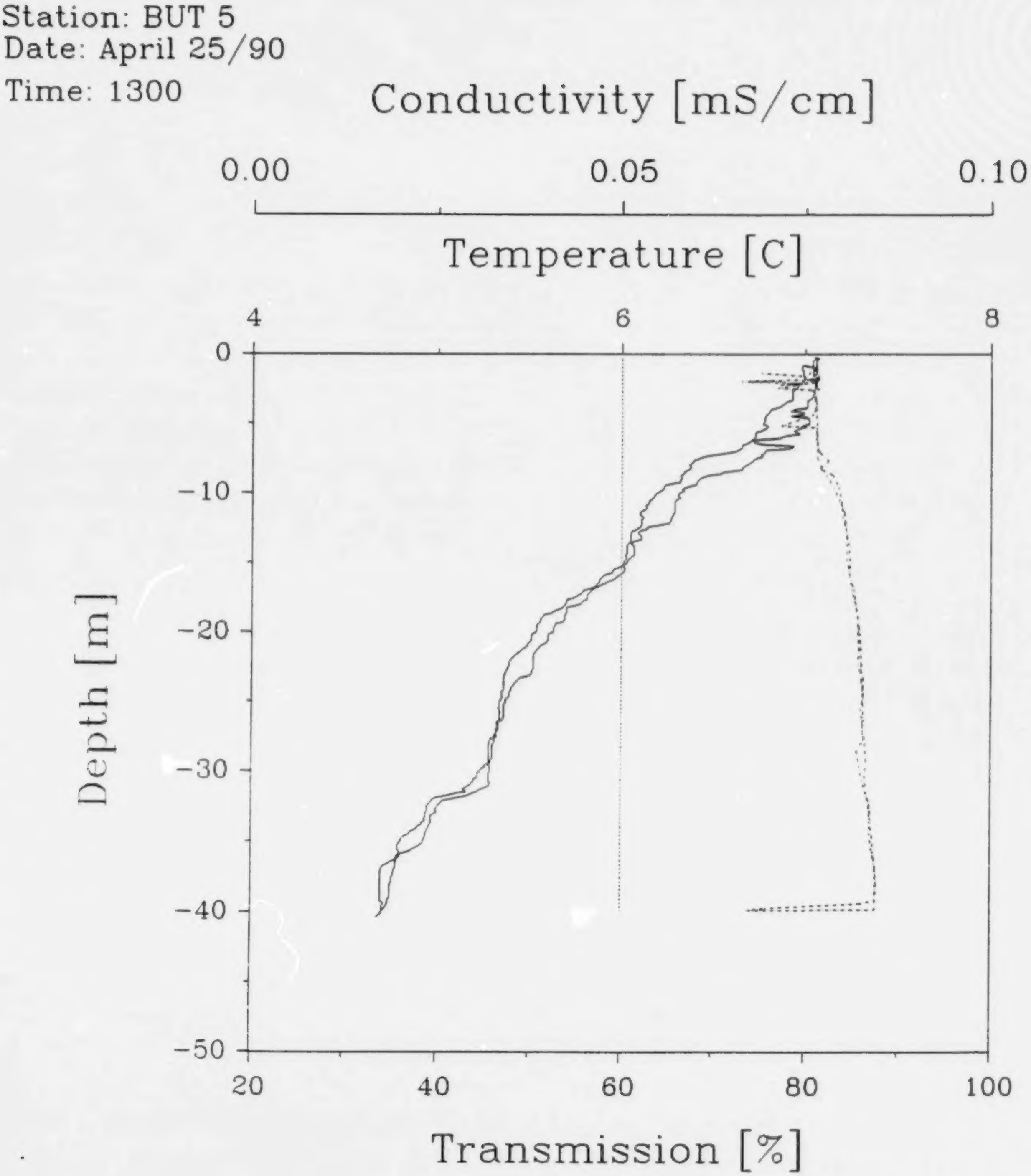

Figure 3-1 Conductivity (---), temperature (——) and percent transmission (•----•) profiles for Station BUT 5.

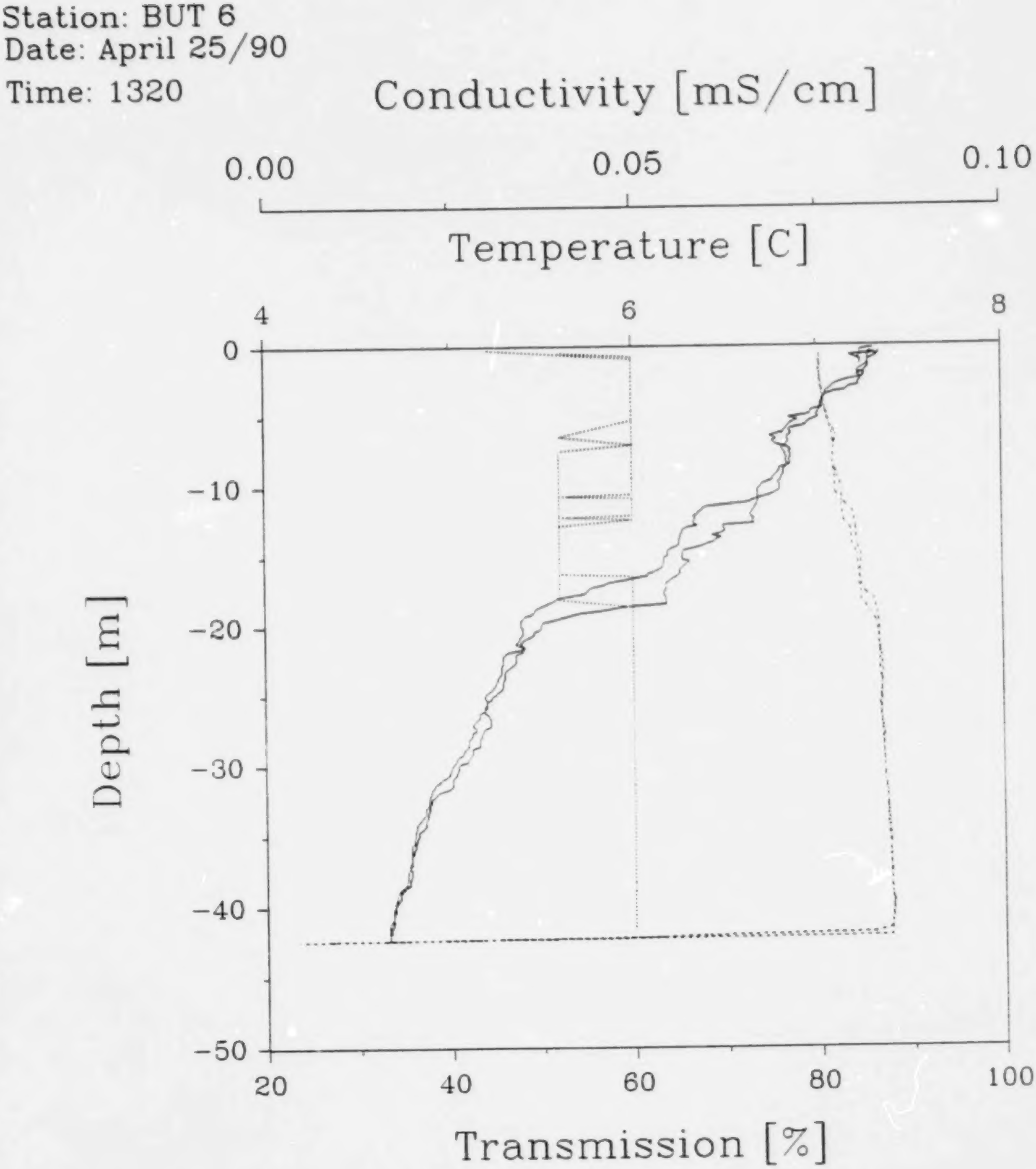

Figure 3-2 Conductivity (---), temperature (——) and percent transmission (•····•) profiles for Station BUT 6.

Station: BUT 4
Date: April 25/90
Time: 1400

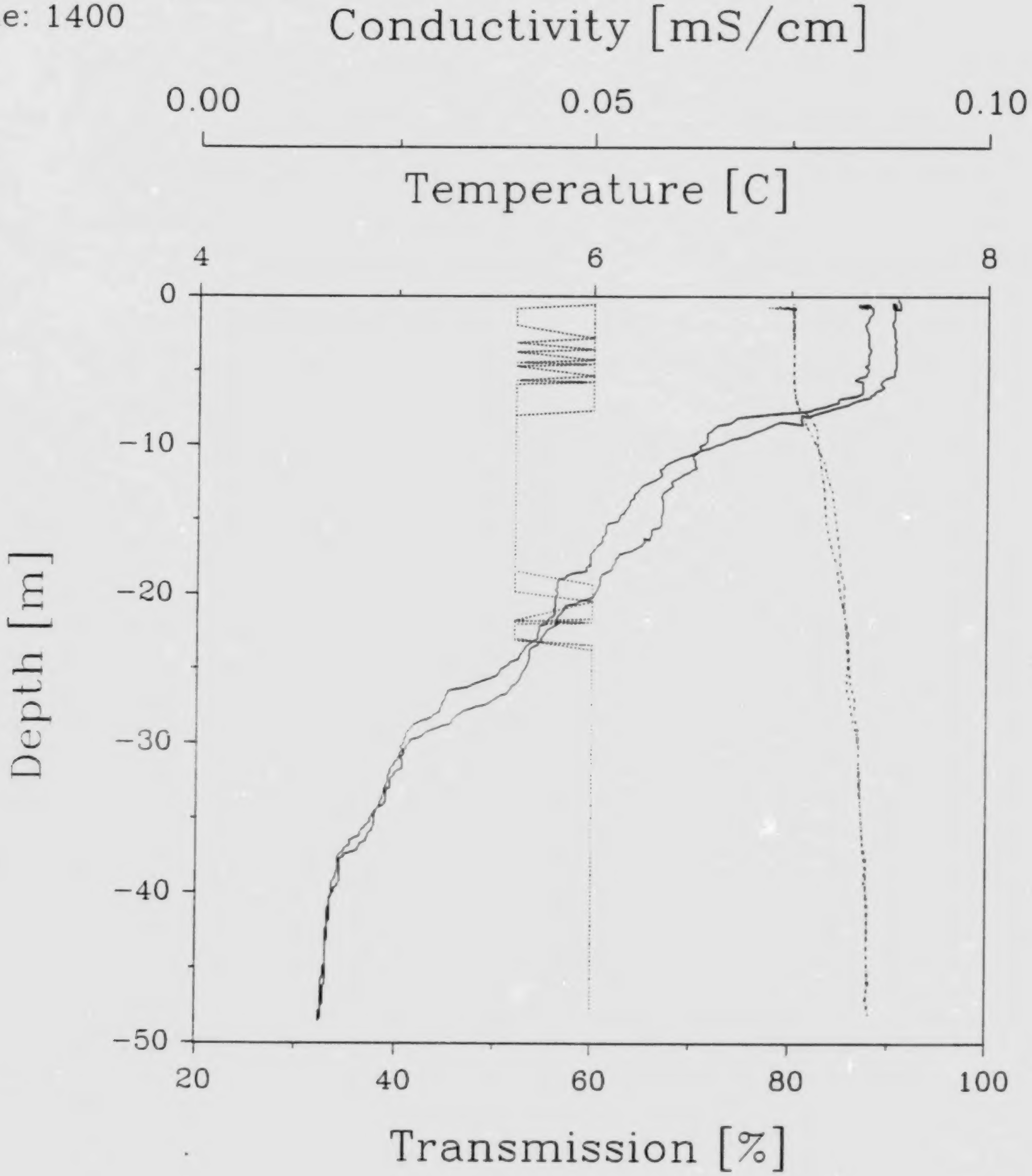

Figure 3-3 Conductivity (---), temperature (——) and percent transmission (•-•-•) profiles for Station BUT 4.

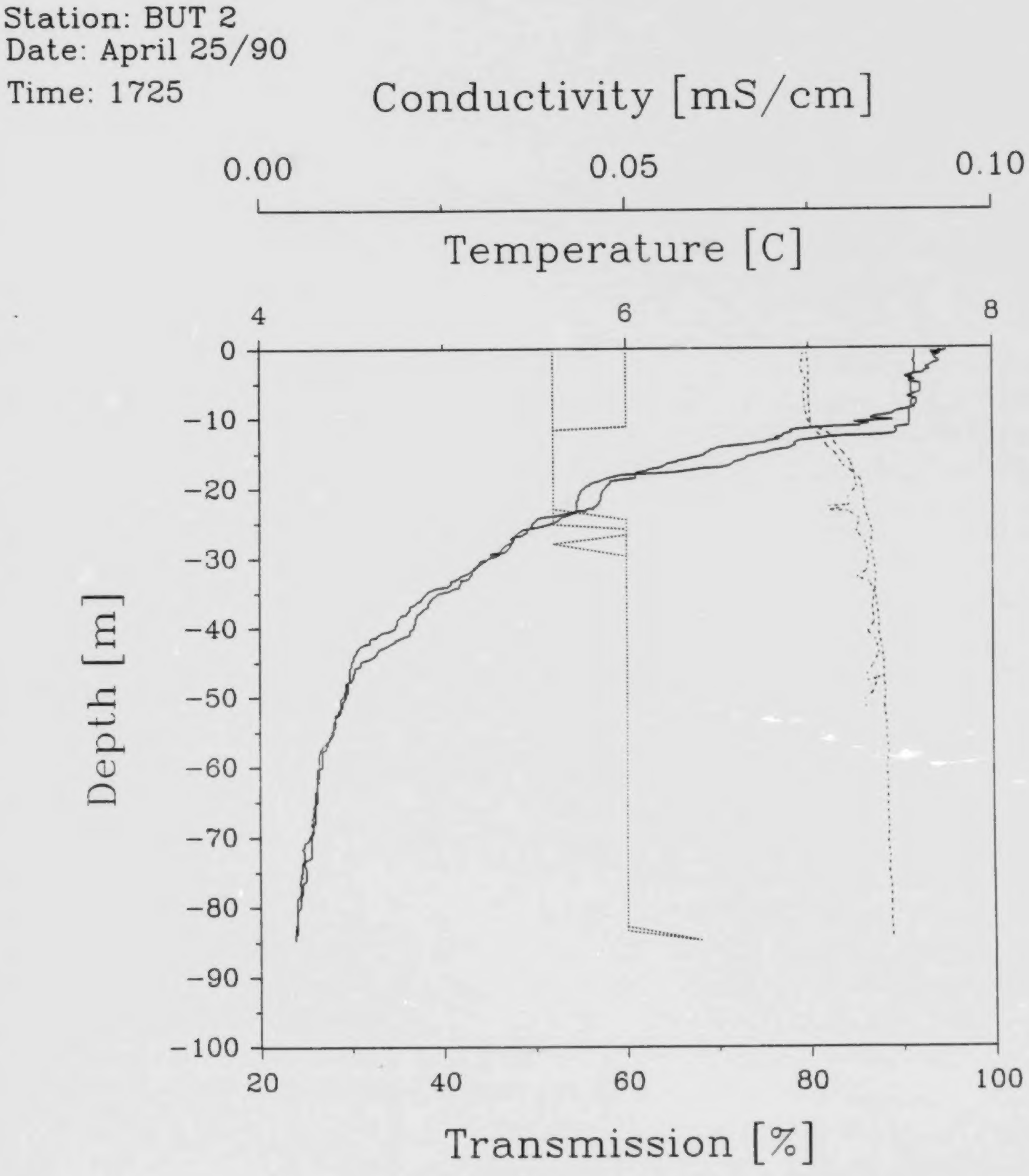

Figure 3-4 Conductivity (---), temperature (——) and percent transmission (•----•) profiles for Station BUT 2.

the deepest station in the lake (BUT 2). Aluminum concentrations ranged from 0.22 to 0.40 mg L^{-1} with the highest concentration found at station BUT 2 near the bottom. Arsenic concentrations ranged from <0.0001 to 0.0005 mg L^{-1} with the highest concentrations being found at the surface and stations closest to Myra Creek. Copper concentrations ranged from <0.001 to 0.005 mg L^{-1} with the highest concentration found at station BUT 2 near the bottom. Cadmium was not detected in surface waters but was detected as concentrations of up to 0.0004 mg L^{-1} at depth at all stations except station BUT 4. Iron, mercury and nickel were consistently below detection limits at all sites and depths. Lead was detected (0.002 mg L^{-1}) only at station BUT 2 near the bottom. Manganese concentrations ranged from <0.005 to 0.014 mg L^{-1} with the highest concentrations found with increasing depth. Zinc concentrations ranged from 0.22 to 0.052 mg L^{-1} with lowest and highest values found at station BUT 2 at the surface and bottom depths, respectively. Surface concentrations of zinc ranged from 0.022 to 0.033 mg L^{-1}, while bottom concentrations ranged from 0.035 to 0.052 mg L^{-1}.

Historical water quality data obtained from the B.C. Ministry of Environment, Waste Management Branch were extracted from the SEAM database for two sites (Sites 0130080 and 0130082) and are presented in Appendix C. Summary climate data for the Myra Creek weather station including total monthly precipitation (rain and snow) and monthly mean maximum and minimum temperatures are also presented in Appendix C for the years 1968 to 1989.

3.2 Solid-phase Chemistry and Mineralogy of Cores

The concentrations of major (Fe, Ti, Ca, K, Si, Al, Mg, P and Na) and minor elements (Zn, Pb, Cu, Ni, Co, Mn, Ba, Cr, V, Sr and Rb) were determined by X-ray fluorescence spectrometry as described in Appendix B. Results are listed in Appendix D. The concentrations of total carbon, nitrogen and sulphur were determined using elemental analysis as described in Appendix B; results are tabulated in Appendix E. Mineralogy was determined in a smaller number of samples by X-ray diffractometry, as outlined in Appendix B; results are tabulated in Appendix F. Of the four cores, BUT 2, 4 and 5 consist of three strata, with each layer well-defined by a number of the measured elemental distributions. The thin topmost layer in each of these three cores (described in the core logs as natural sediments) is in fact a mixture of tailings and natural sediments, as can be readily seen in the diminished but significant concentrations of Zn, Cu, Pb, Ba and S in the upper few cm (Figures 3-5, 3-6, 3-7 and Appendices D and E).

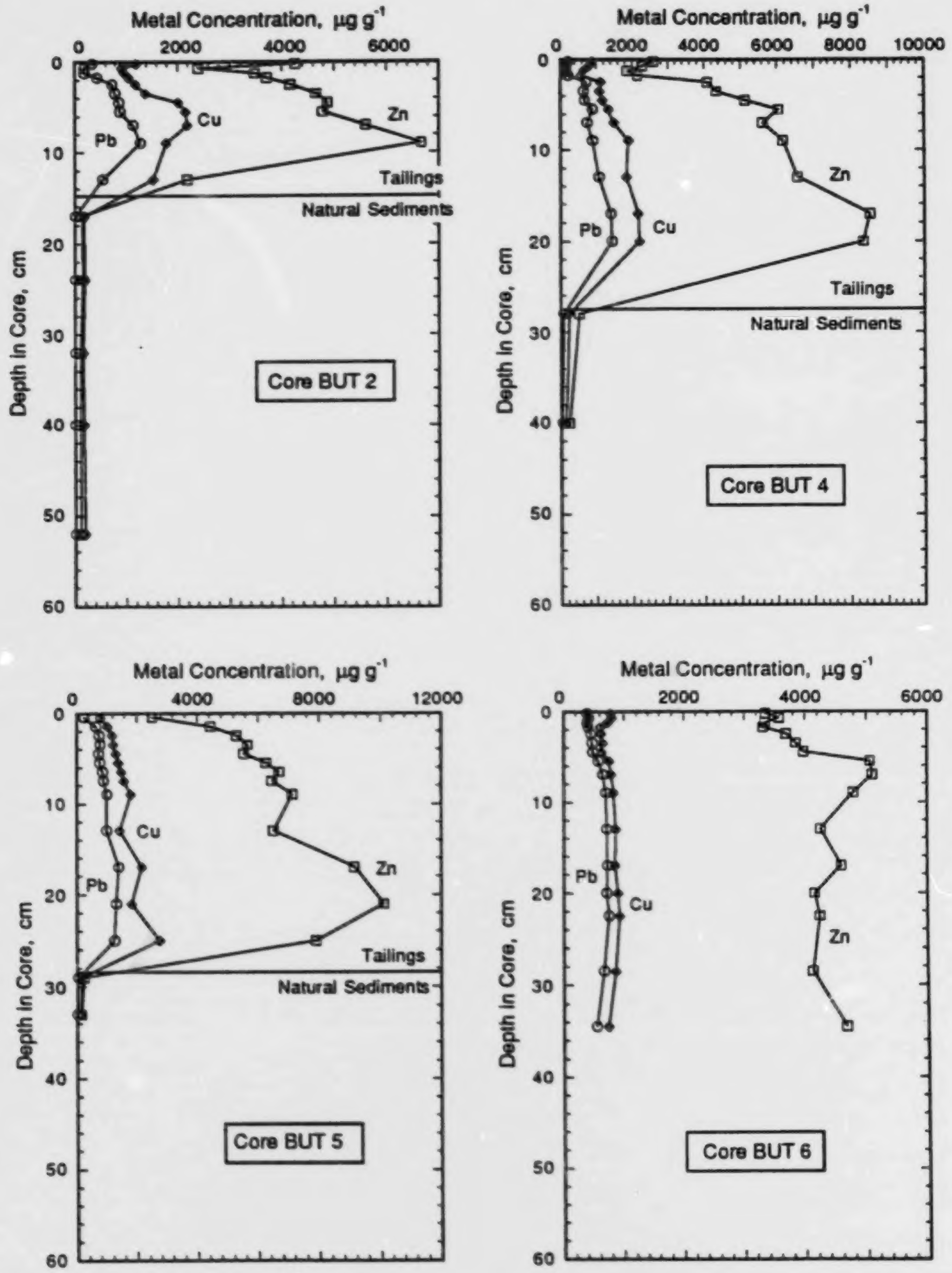

Figure 3-5 Sedimentary Pb, Zn and Cu concentration profiles in cores from the south basin of Buttle Lake. Note the variable scales on the abscissae.

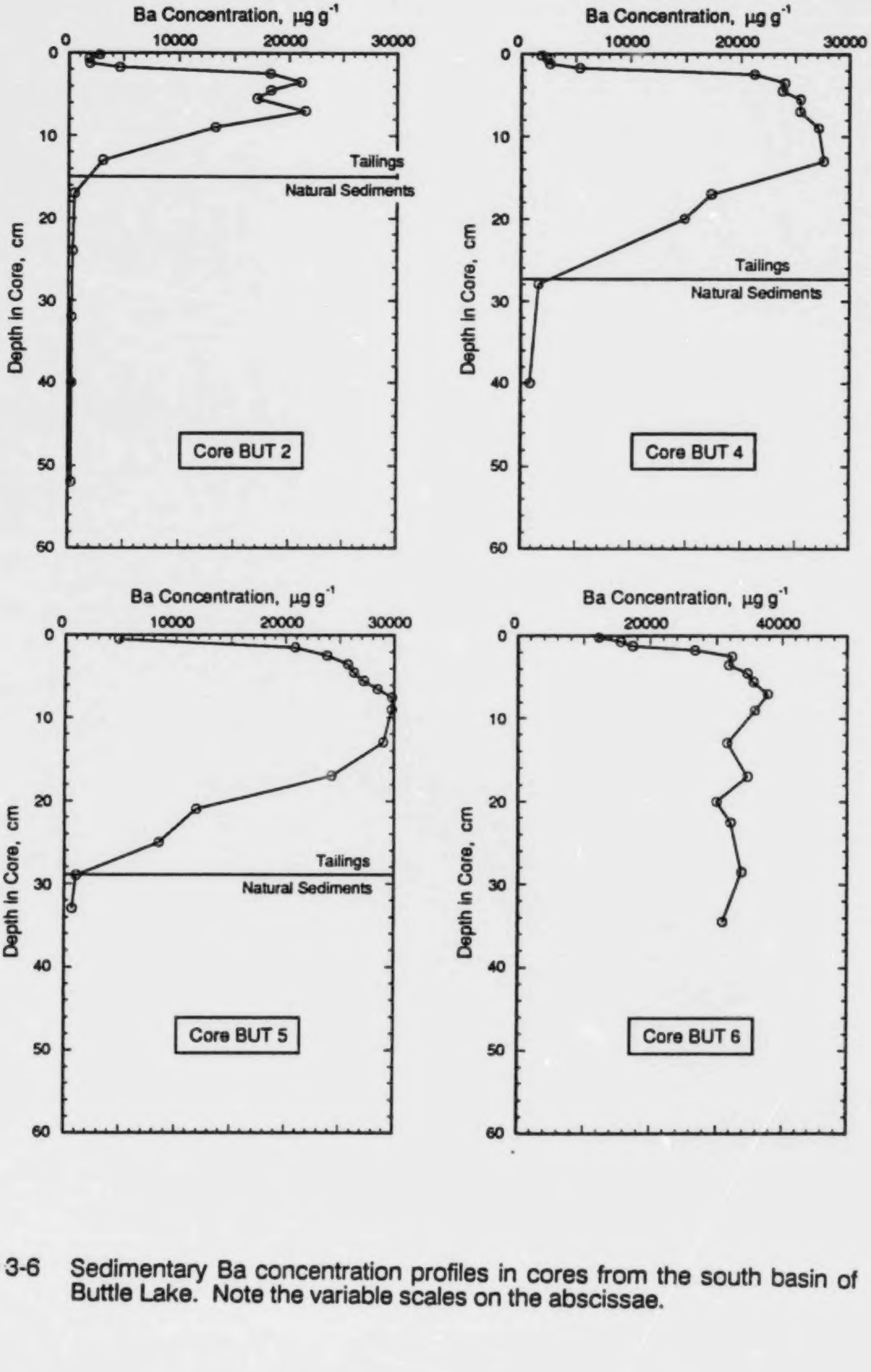

Figure 3-6 Sedimentary Ba concentration profiles in cores from the south basin of Buttle Lake. Note the variable scales on the abscissae.

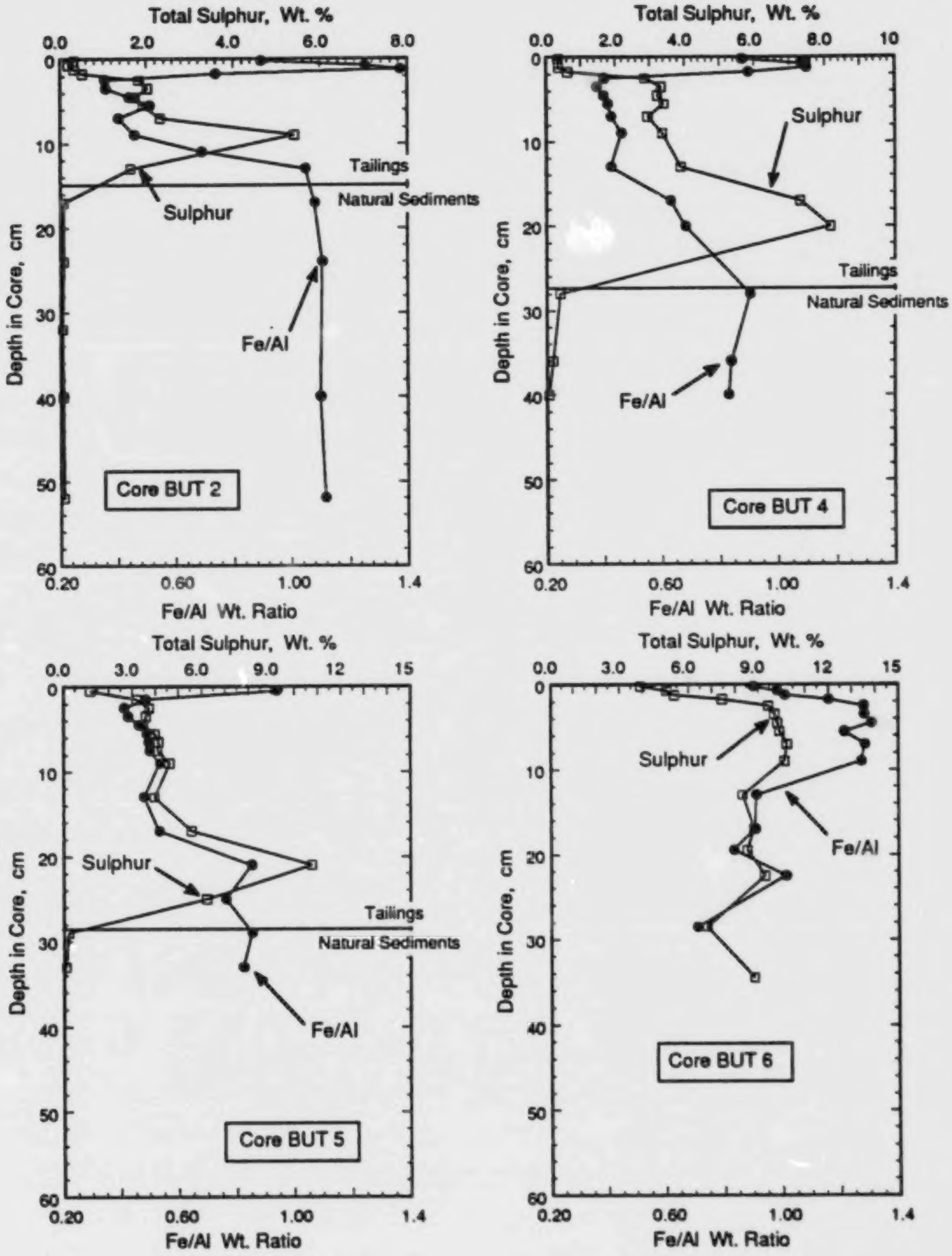

Figure 3-7 Sedimentary S concentration and Fe/Al wt. ratio profiles in cores from the south basin of Buttle Lake. Note the variable scales on the abscissae.

Zinc concentrations, for example, exceed 2000 μg g^{-1} in the upper 10 mm of cores BUT 4 and 5 and 4000 μg g^{-1} in the upper 5 mm of core BUT 2. Below the surface horizon in BUT 2, 4 and 5, the sediment composition is dominated by a tailings layer, again as shown by the Zn, Cu and Pb profiles (Figure 3-5). The thickness of this stratum increases with proximity to the former discharge point (~15 cm at BUT 2, ~25 cm at BUT 4, and ~28 cm at BUT 5). Note that in each case, variations in the heavy metal contents are stratigraphically consistent. The highest Zn concentrations, for example, occur toward the base of the tailings layer at the three sites. Natural, essentially tailings-free sediments underlie the tails layer in BUT 2, 4 and 5; Zn, Pb and Cu contents in the lower decimetre of these cores are at typical background levels (Figure 3-5 and Appendix D). Visual observations (Appendix A) and the distributions of heavy metals and sulphur (Figures 3-5, 3-6 and 3-7) indicate that core BUT 6 consists exclusively of tailings, with the exception of the upper 2 cm, which include an admixture of natural sediments. The best evidence for the latter observation is provided by the organic carbon and nitrogen profiles; both elements are strongly enriched in the uppermost 2 cm, and greatly depleted in the tailings (Figure 3-8 and Appendix E). The carbon and nitrogen distributions also clearly define the tri-layer stratigraphy which characterizes the other three cores. The C/N ratio profiles for the four cores are presented in Figure 3-9. High measured barium concentrations indicate that the tailings contain substantial concentrations of a barium mineral, presumably barite. Barite was not detected by x-ray diffractometry, however. Of the other trace elements measured, Co, Ni, Mn and Cr are depleted in the tailings relative to their typical concentrations in natural sediments, and Zr, Rb and Sr are relatively enriched. The distributions of the latter trio reflect mineralogical contrasts between the tailings and natural sediments in the basin.

Major element distributions demonstrate clearly that the tailings are composed of different aluminosilicate minerals than the natural fluvial detritus deposited in the basin. Low Na/Al and Si/Al ratios (Figure 3-10) and high K/Al ratios in the tailings (Figure 3-11) are particularly distinct when compared to the natural sediments in the lowermost strata of cores BUT 2, 4 and 5. X-ray diffractograms indicate that quartz and chlorite are common in both tailings and natural sediments (Appendix F) while plagioclase feldspar is much less common in the former. Muscovite and pyrite are particularly abundant in the tailings; the latter was not detectable in the natural sediments. These differences in mineralogy explain the contrasts seen in the elemental ratios profiled in Figures 3-10 and 3-11. The high K/Al and low Si/Al and Mg/Al ratios characteristic of

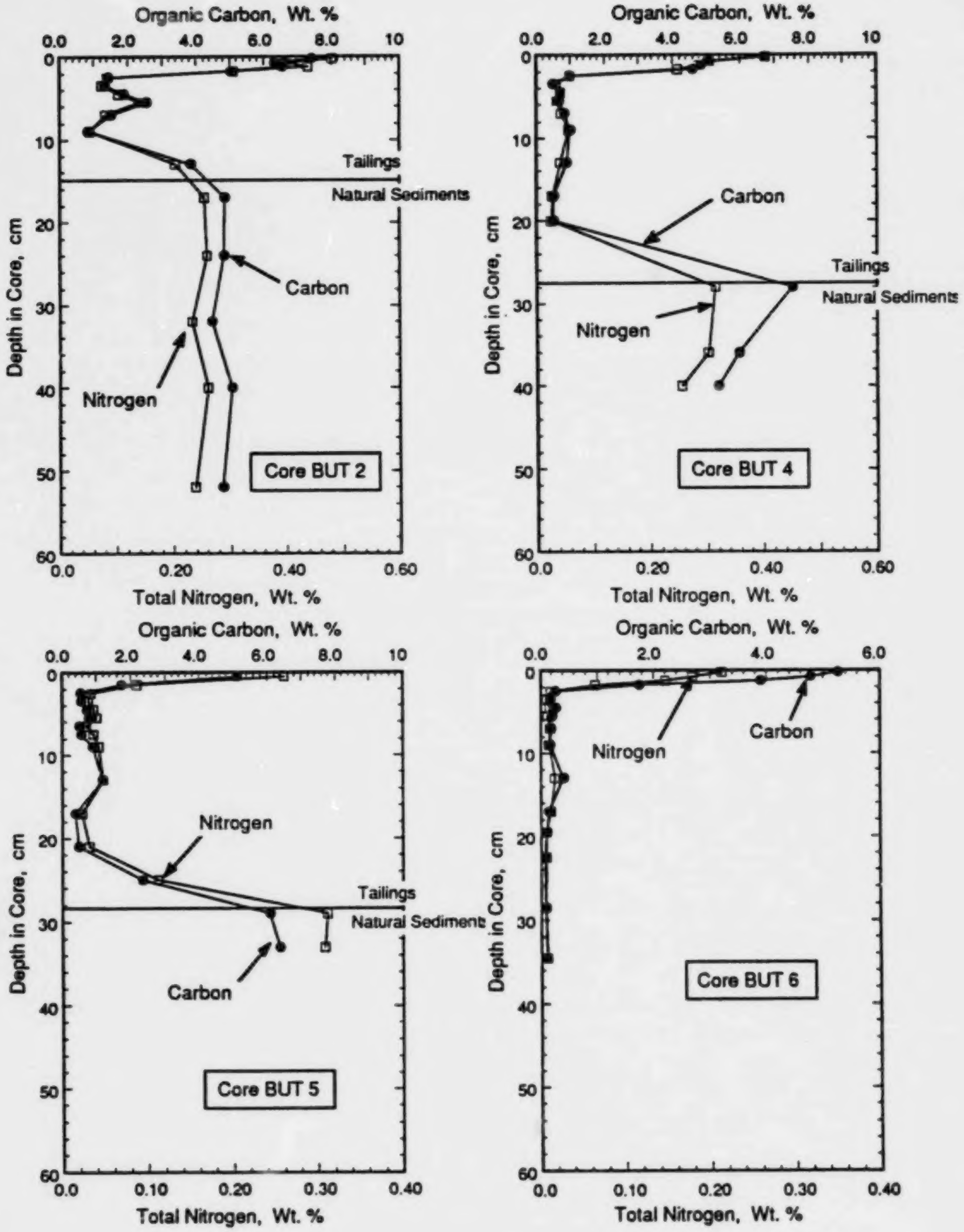

Figure 3-8 Sedimentary organic carbon and nitrogen profiles in cores from the south basin of Buttle Lake. Note the variable scales on the abscissae.

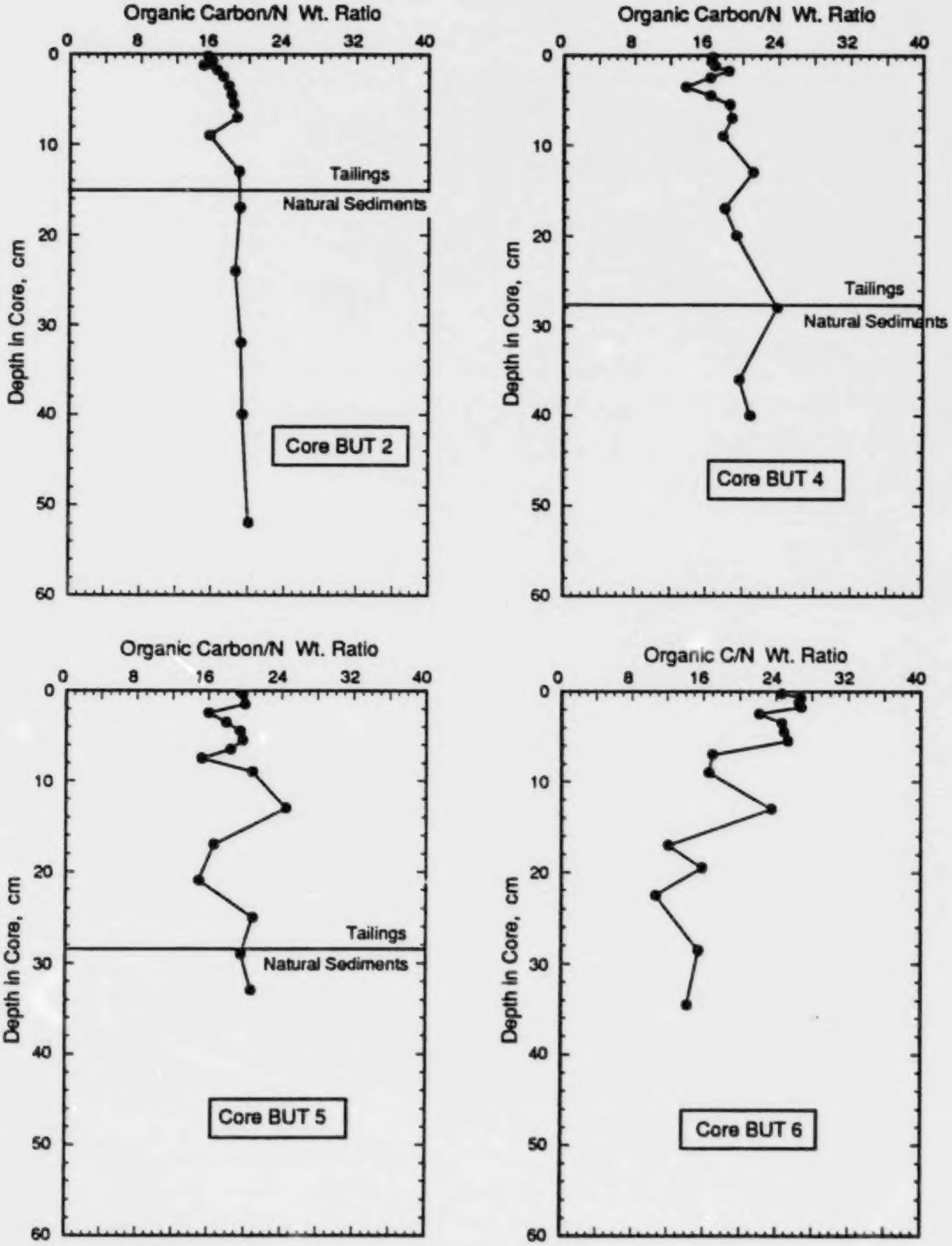

Figure 3-9 Organic carbon/nitrogen wt. ratio profiles in cores from the south basin of Buttle Lake.

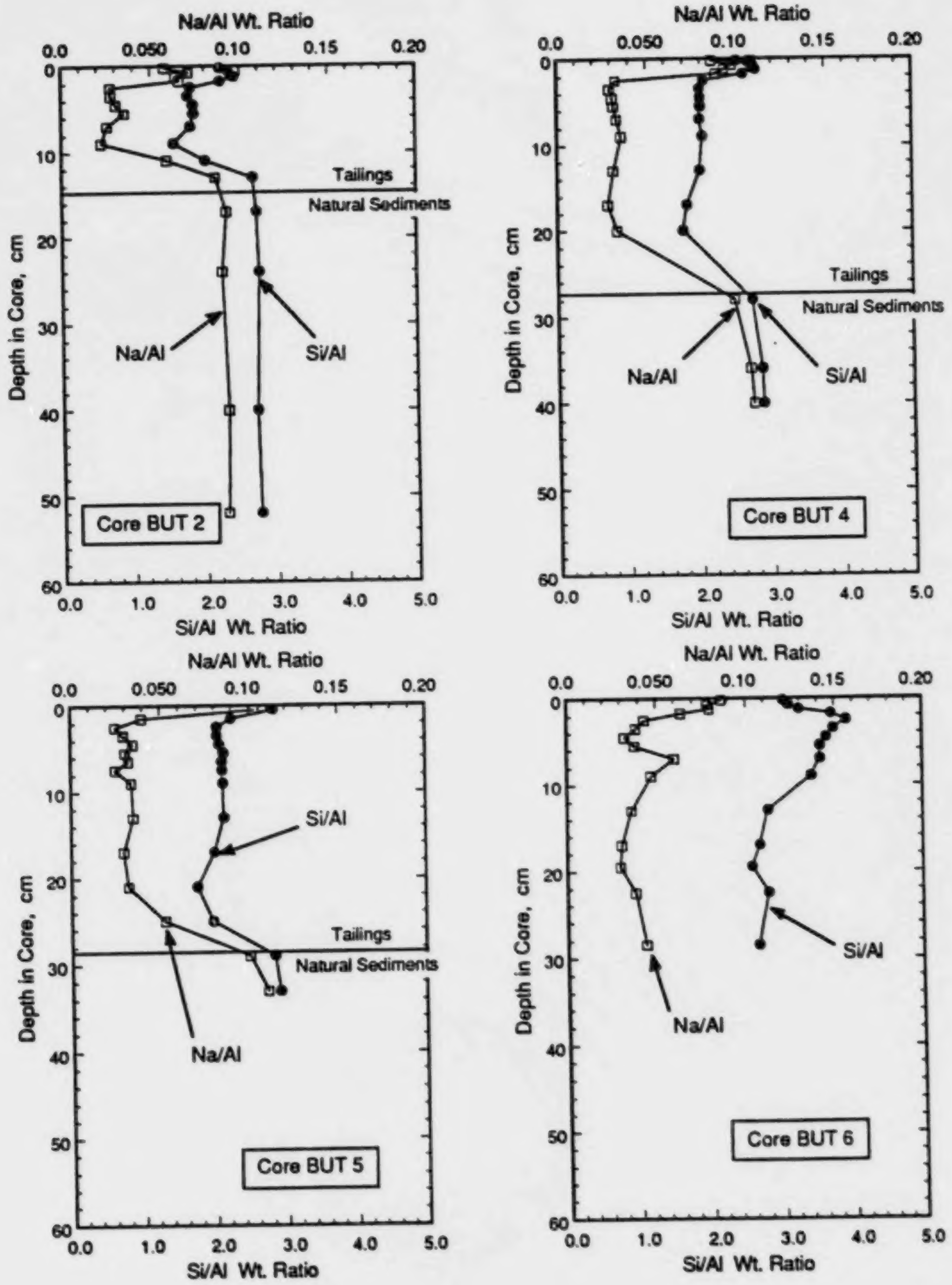

Figure 3-10 Sedimentary Si/Al and Na/Al wt. ratio profiles in cores from the south basin of Buttle Lake.

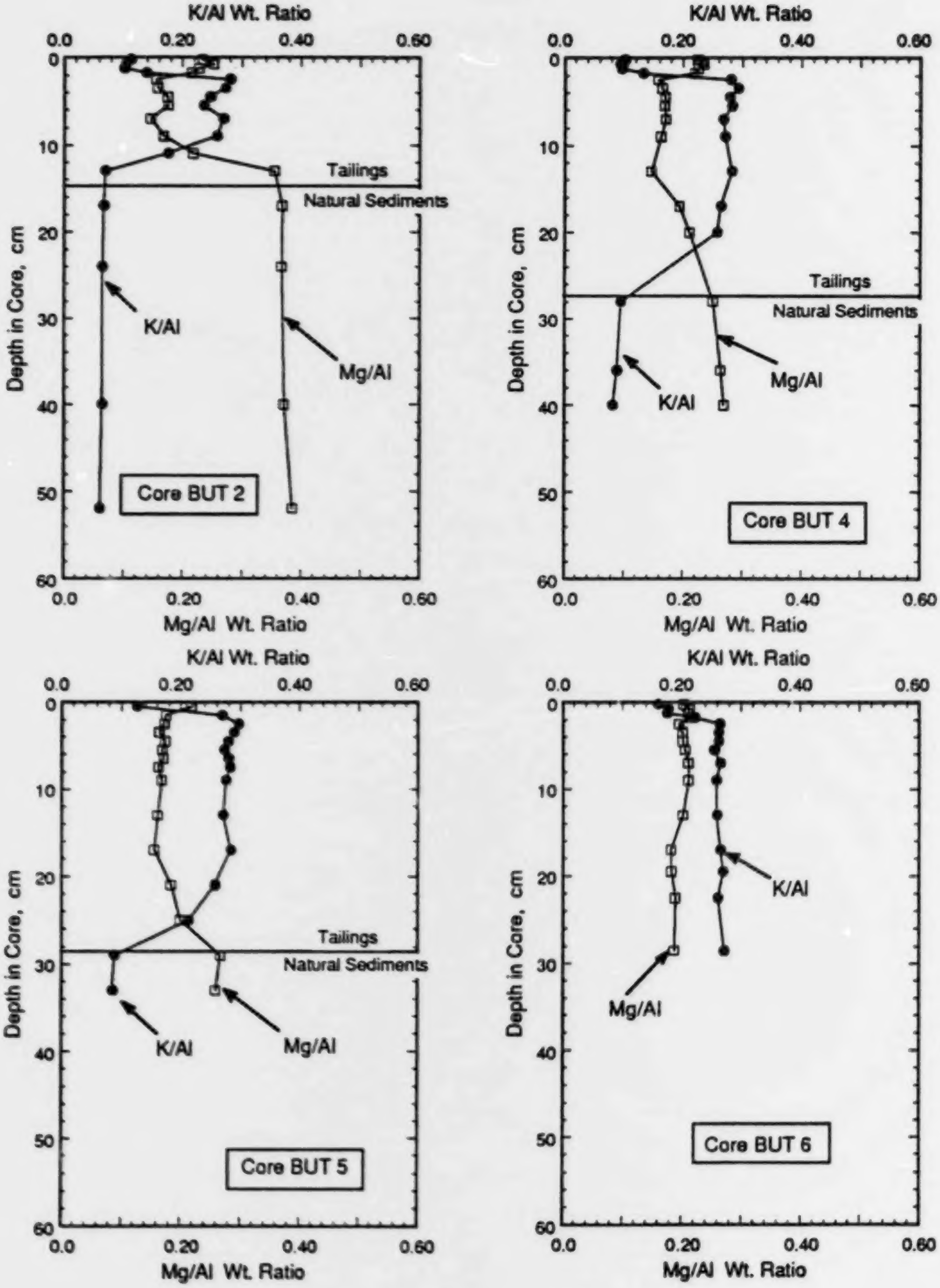

Figure 3-11 Sedimentary K/Al and Mg/Al wt. ratio profiles in cores from the south basin of Buttle Lake.

the tailings reflect the abundance of K- and Al-rich muscovite in these deposits. Similarly, the low Na/Al ratio in the tails is consistent with the lower plagioclase content indicated by the XRD results. The high S concentration in the tailings (Figure 3-7), noted above, reflects the presence of abundant pyrite gangue in the ore.

Manganese is markedly enriched in the surface sediments at all four core locations (Figure 3-12). Concentrations reach a maximum of nearly 3 wt. % (30,000 μg g^{-1}) in the upper 5 mm of BUT 2. Iron concentrations, plotted as Fe/Al to emphasize mineralogic contrasts, are similarly high in the upper 2 cm at sites BUT 2, 4 and 5, but no enrichment is seen at the top of core BUT 6 (Figure 3-12). As will be discussed further (see Section 4.3), the Mn and Fe distributions are influenced by diagenetic recycling as well as the recent accumulation of Fe- and Mn-rich fluvial detritus. High Fe/Al ratios in core BUT 6 (Figure 3-12) correlate well with the sulphur distribution (Figure 3-7) reflecting the high pyrite content in the tailings at this site.

3.3 Interstitial Water

Filtered pore waters were analyzed for dissolved Zn, Cu, Pb, Cd, Fe and Mn as described in Appendix B. All concentration data are listed in Appendix G. Analytical detection limits for all metals (Appendix B) are significantly lower in this study than in Pedersen (1983a), reflecting improvements in instrumentation. In addition, much higher resolution sampling of the cores for pore waters was used in this work compared to the low-resolution approach employed in 1983. As a result, dissolved metal distributions are reported with much greater detail in this study. One other major contrast exists between the current and the previous work; the south basin waters in the early 1980's contained very high dissolved metal concentrations, while as noted earlier, present levels have decreased significantly. Because of these differences, caution must be applied in drawing direct comparisons between the 1983 results and those presented here.

Dissolved Cu concentrations in all four 1989 cores are similar to the levels reported previously by Pedersen (1983a). Cu contents in supernatant (core-top) waters (Appendix G) are typically 0.04 ± 0.01 mmol L^{-1} (about 3 μg L^{-1}), close to the Environment Canada water quality guideline of 2 μg L^{-1}, and similar to measurements made in bottom waters reported by Deniseger et al. (1988) and more recently, by the Waste Management Branch (L. Erickson, pers. comm.). In general, concentrations are low in the cores with the exception of a limited number of discrete horizons at depth

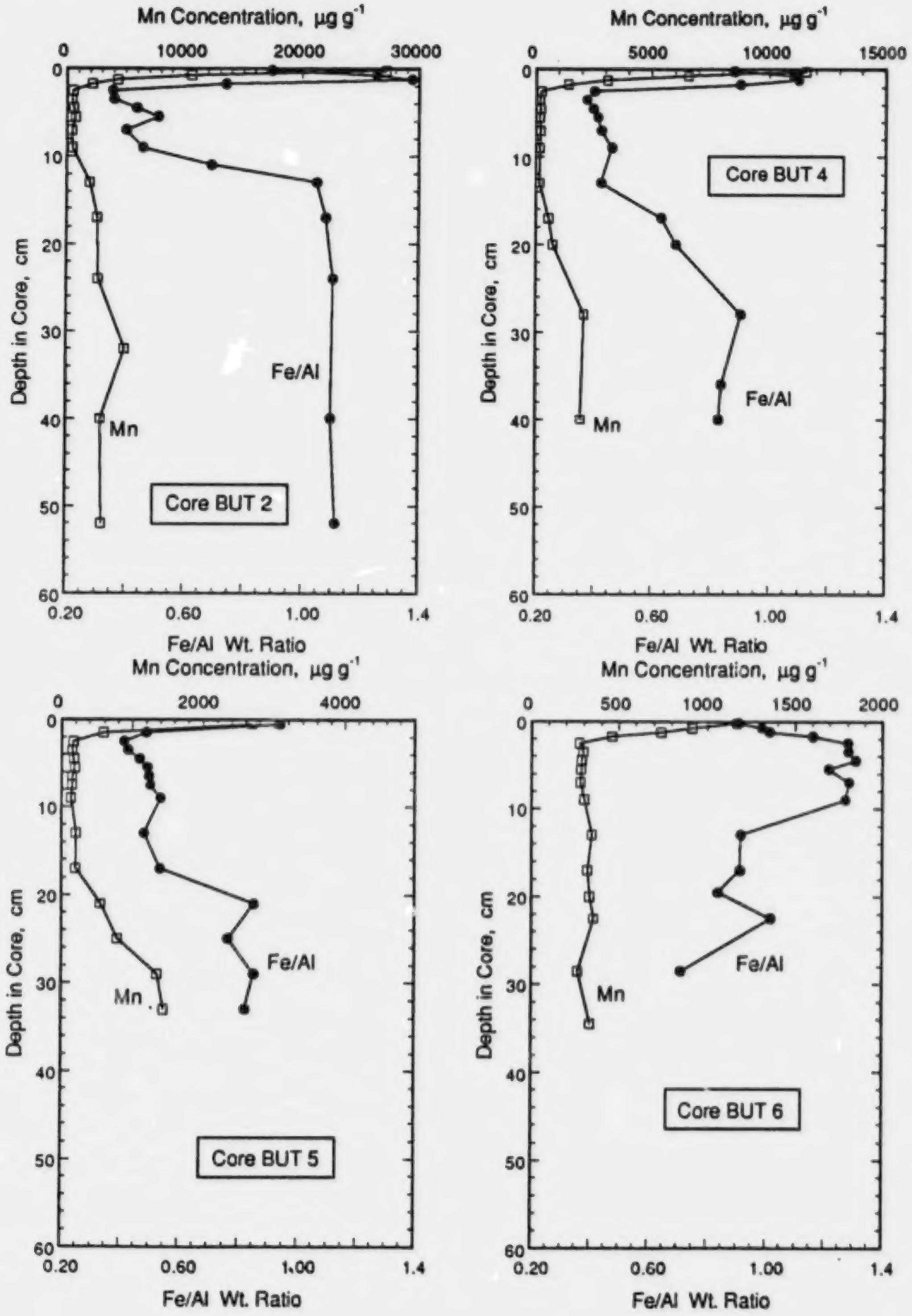

Figure 3-12 Sedimentary Mn concentration and Fe/Al wt. ratio profiles in cores from the south basin of Buttle Lake. Note the variable scales on the abscissae for Mn.

where levels are considerably enriched, reaching as much as 5 μmol L^{-1} (Figure 3-13). Dissolved Zn values in the supernatant waters at stations BUT 2, 5 and 6 are all about 1 μmol L^{-1} (65 μg L^{-1}), again similar to levels measured recently in bottom water (Deniseger et al., 1988; L. Erickson, pers. comm.) and about double the federal water quality criteria of 30 μg L^{-1} (CCREM, 1987). Supernatant water in core BUT 4 contained twice as much dissolved Zn (~2 μmol L^{-1}) as was measured at the other three sites. Concentrations at depth are higher than observed in similar sediments in 1983, with the exception of core BUT 6 (the "pure tailings" core) in which levels are significantly less than in the overlying bottom water, at least in the upper two decimetres (Figure 3-13). It is notable that Zn is enriched in the same discrete horizons as Cu (and Pb and Cd) in all four cores (Figure 3-13). Zn concentrations in these layers reach values as high as 24 μmol L^{-1} (core BUT 4, 7 cm depth).

Pb concentrations in supernatant waters are relatively low, reaching a maximum of 0.013 μmol L^{-1} (<3 μg L^{-1}) in core BUT 6. This level is less than the Environment Canada criteria (5 μg L^{-1}) by about a factor of two. Concentrations in the upper two cm at all four sites are similarly low (Figure 3-13; Appendix G). However, as observed for the other heavy metals, Pb is enriched in discrete zones at depth at all four sites (Figure 3-13).

Cd levels are very low (<0.5 μg L^{-1} or 5 nmol L^{-1}) in the supernatant waters at all locations (Appendix G). These measurements are entirely consistent with the values reported by Deniseger et al. (1988) and measured recently by the Waste Management Branch (L. Erickson, pers. comm.). Cd concentrations are extremely low (typically <0.2 nmol L^{-1}) in core BUT 6 ("pure tailings"). At depth at the other sites, concentrations are also notably low, with two exceptions: first, Cd is enriched in the same discrete zones as the Zn, Cu and Pb (compare Figure 3-14 with Figure 3-13), although the maximum concentrations reached do not exceed 10 nmol L^{-1} (about 1 μg L^{-1}); second, in two of the four cores (BUT 2 and 4), the Cd level in the upper 5 mm is higher by a factor of about two than in the overlying supernatant or the immediately underlying pore water (Figure 3-14).

Dissolved Mn and Fe levels in pore waters are enriched relative to supernatant water within millimetres of the sediment-water interface at each station (Appendix G). Concentrations in the tri-layer cores reach extremely high levels at greater depths,exceeding 1 mmol L^{-1} Fe (>75,000 μg L^{-1}) in BUT 4 and 5 (Figure 3-15) and 250

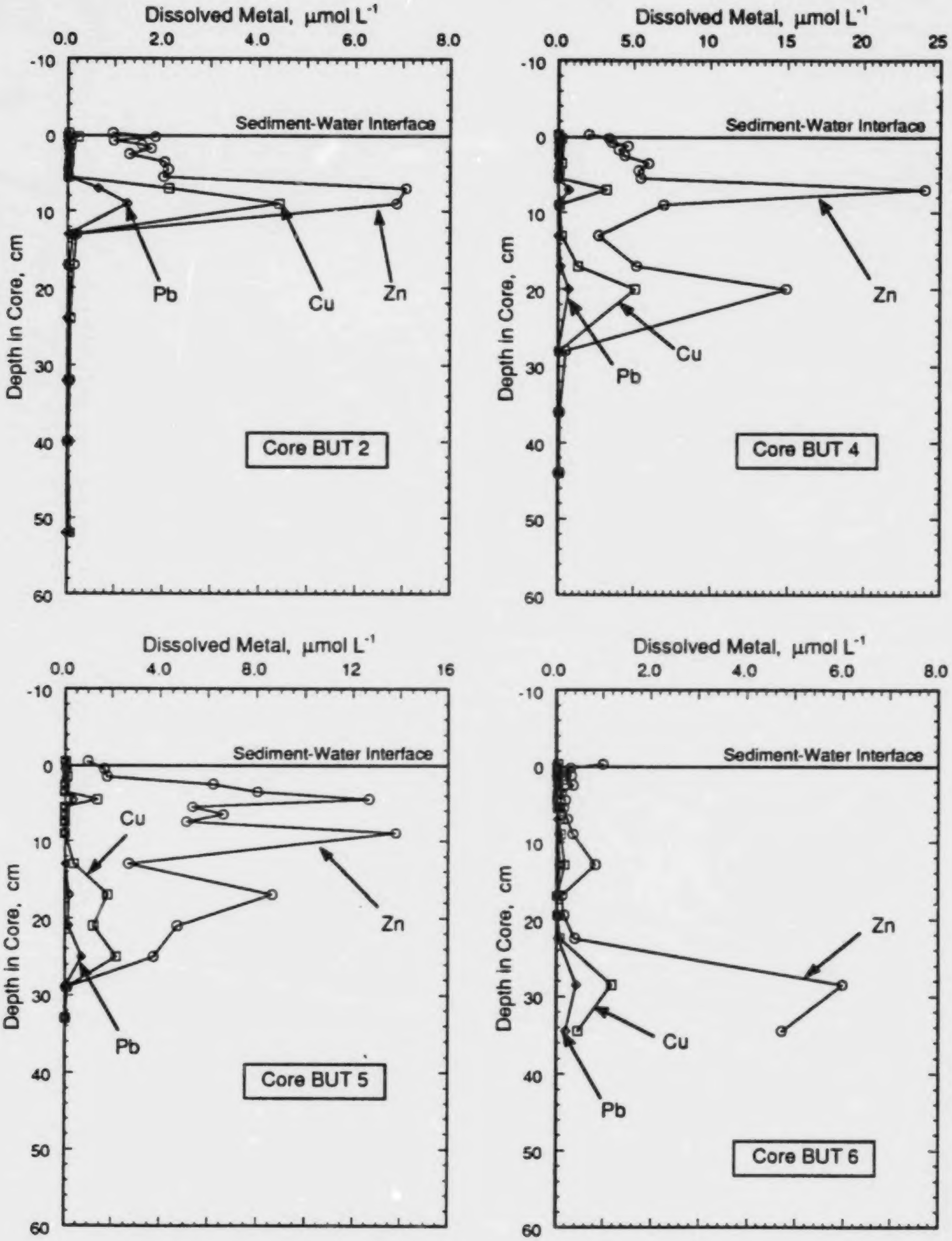

Figure 3-13 Dissolved Zn, Cu and Pb profiles in pore waters extracted from cores collected in the south basin of Buttle Lake. Note the variable scales on the abscissae.

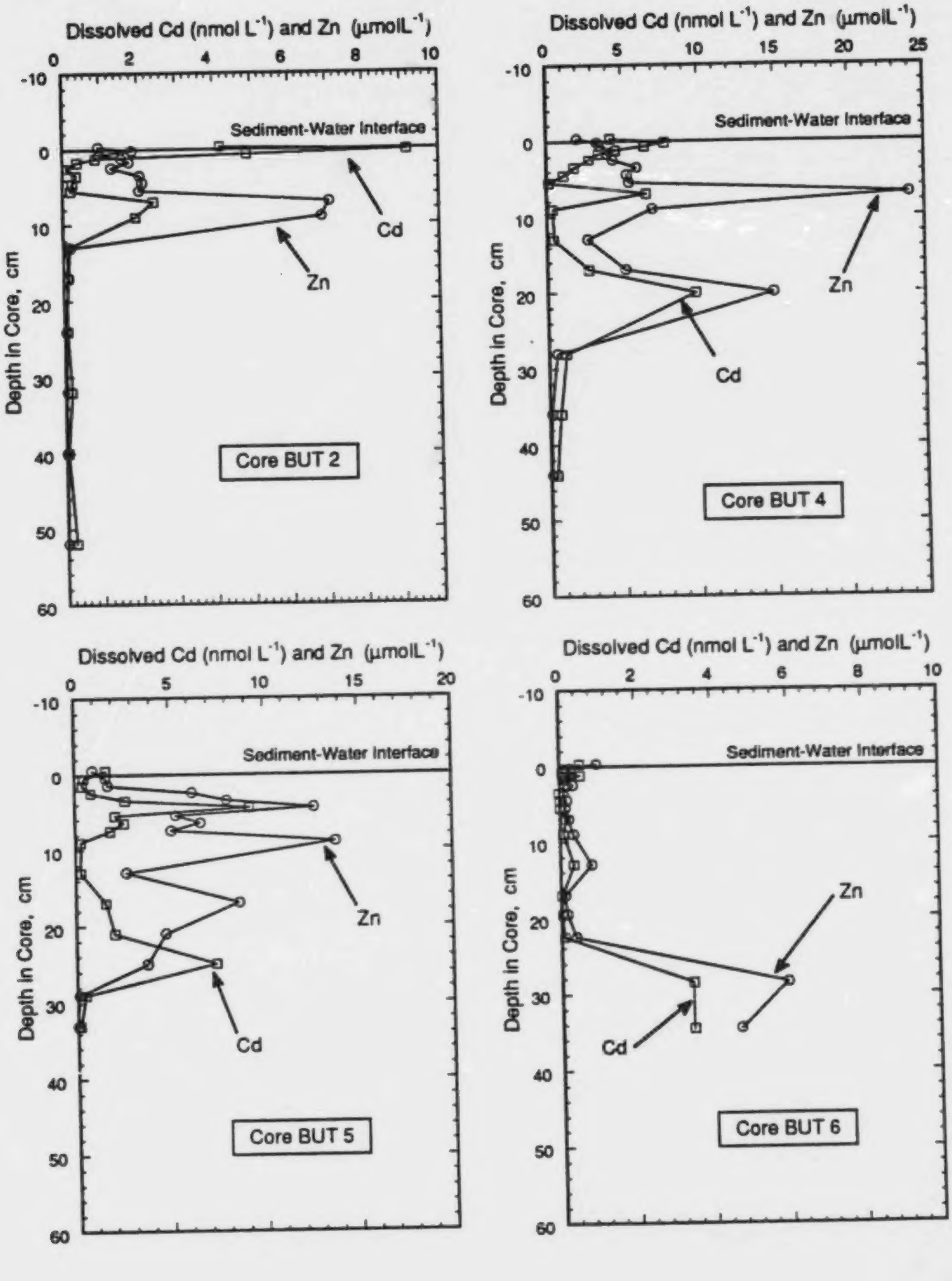

Figure 3-14 Dissolved Zn and Cd profiles in pore waters extracted from cores collected in the south basin of Buttle Lake. Note the variable scales on the abscissae.

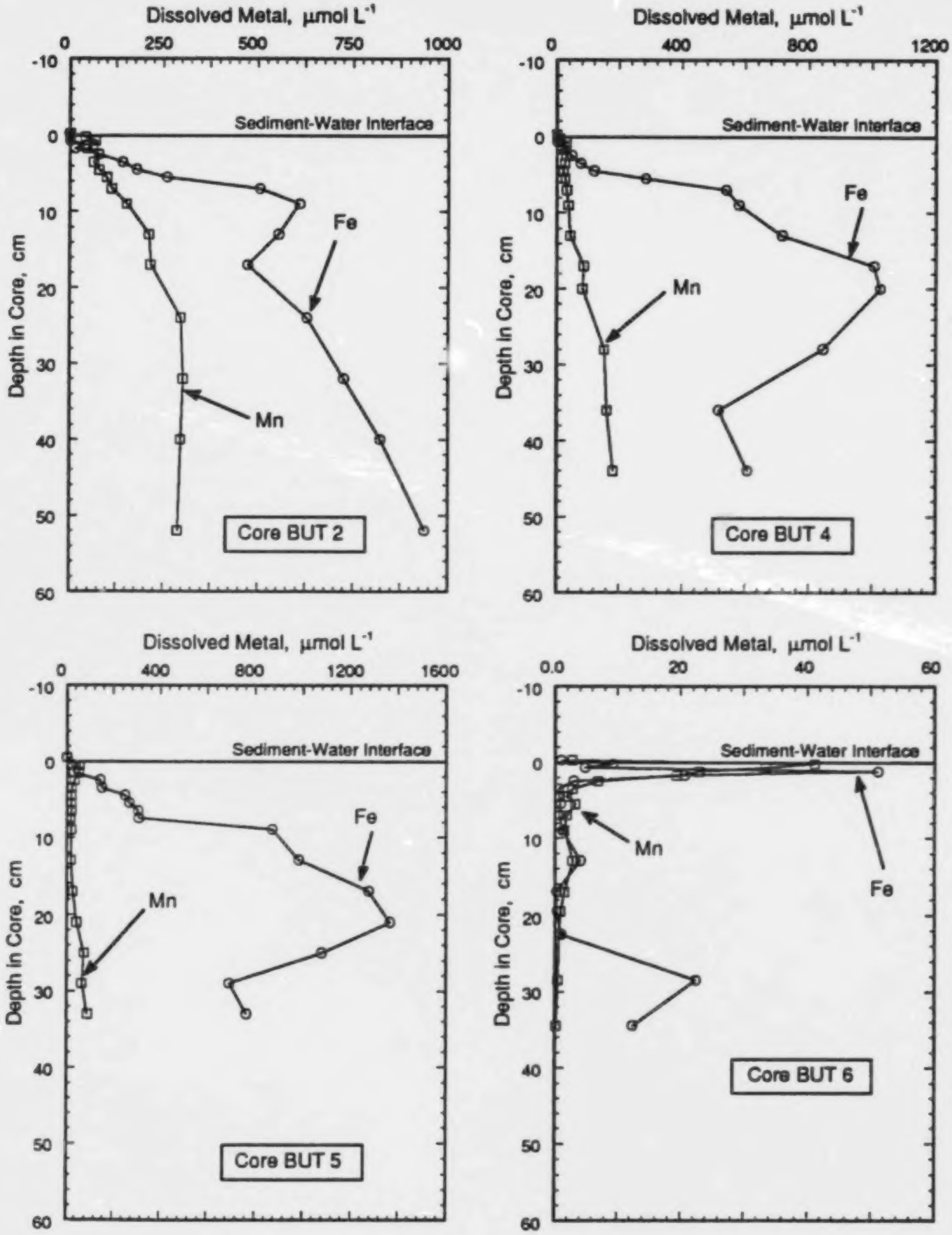

Figure 3-15 Dissolved Mn and Fe profiles in pore waters extracted from cores collected in the south basin of Buttle Lake. Note the variable scales on the abscissae.

μmol L^{-1} Mn (>15,000 μg L^{-1}) in BUT 2. Pedersen (1983a) reported concentrations of equivalent order at depth in natural sediments at similar sites in the south basin. In the "pure tailings" core (BUT 6), concentrations at depth of both metals are relatively low (Figure 3-15).

4 - Discussion

4.0 DISCUSSION

4.1 Water Quality

Buttle Lake is characterized as a soft-water, oligotrophic lake (Nordin et al., 1985). Sampling of the south basin in April 1990 indicated a hardness of 30 - 40 mg L^{-1} $CaCO_3$ and low nutrient concentrations of up to 0.004, 0.13 and 4.7 mg L^{-1} for total phosphorus, nitrate plus nitrite and reactive silicate, respectively. The nutrient concentrations are likely close to the maximum spring overturn concentrations. The lake is well oxygenated, as is typical of oligotrophic lakes, with dissolved oxygen concentrations above 5.0 mg L^{-1} (generally >10 mg L^{-1}) both seasonally and throughout the water column (WMB - SEAM data in Appendix C; Nordin et al., 1985).

Temperature profiles collected in April 1990 indicated surface warming had started. The south basin shows a typical coastal lake stratification pattern. The water column is isothermal from January through March; warming begins in April and produces maximum summer stratification in August, while cooling occurs during September through December (WMB - SEAM data in Appendix C; Nordin et al., 1985). The stratification pattern affects the vertical pattern of inflows into a lake. During the winter, Myra Creek inflows on or near the surface but during the summer it enters as interflow at a depth of 10 - 30 m (WMB - SEAM data Appendix C; Nordin et al., 1985). This is important to note as Myra Creek is an anthropogenic source of metals loading to Buttle lake. High metal loadings have also been occasionally observed in Thelwood Creek with dissolved zinc concentrations as high as 3.24 mg L^{-1} recorded (B.C. Research, 1980). The metals likely originate from deposits of minerals in lenses and in glacial deposits in the drainage basin. Disturbance of these deposits and exposure to air by slides, erosion, etc. could cause high metal loadings in Thelwood Creek.

During sampling in April 1990 the south basin of Buttle Lake was characterized by high transmissibility, low turbidity and low suspended solids at all depths. The slightly lower transmissibility in the top 20 m is likely the result of phytoplankton production in this zone. Turbidity data collected in April and May of 1981 indicated very high turbidity in the lower portions (>20 m depth; zero light transmission below 40 m) of this basin during the period of tailings deposition in the lake (Gillie, 1982). The surface waters displayed low turbidity values. The turbidity plume extended past the Narrows at depths of 25 - 50 m for more than 3 km down the lake.

The lake is characterized by low dissolved solids and consequently low conductivity with values being slightly lower at the surface. Conductivity values since 1981 to present have generally ranged between 60 and 95 μmhos cm^{-1} with minimum and maximum values of 39 and 144 μmhos cm^{-1}, respectively, occurring in early 1982 (WMB - SEAM data in Appendix C). Measured anion concentrations are low (e.g., <0.5 mg L^{-1} chloride and 8 to 17 L^{-1} sulphate).

The pH of the south basin has generally ranged from 6.5 to 7.5 but extreme values of <3.0 and >12.0 were found in 1981 and 1982 (WMB - SEAM data in Appendix C). The low alkalinity of the lake (<24.0 mg L^{-1} as $CaCO_3$) indicates a low buffering capacity and susceptibility to alterations in pH.

The low hardness of the lake is significant in that it affects the form and toxicity of numerous heavy metals (CCREM, 1987). Metals generally become more toxic in soft water. The metals that have been of primary concern in Buttle Lake are zinc, copper, cadmium and lead. The concentrations of these metals entering the lake via Myra Creek decreased after the installation of the surface and groundwater collection and treatment system at the Westmin mine site in 1983 (Deniseger et al., 1988). Metals levels in Buttle Lake itself have been decreasing since 1980, but surface metal concentrations have yet to reach background concentrations in the south basin (Table 4-1). Fluctuations in maximum zinc concentration from 1985 to 1989 seem to indicate the lake has not reached equilibrium concentrations (Table 4-1). Variations in annual hydrographs for Thelwood and Myra creeks, fluctuating lake levels and the timing of sampling can greatly influence the metal concentrations observed in the south basin. Therefore, it will be difficult to determine when equilibrium is reached, particularly if loading rates are also varying in the inflow waters.

The surface water samples collected during this study were within objectives suggested by Nordin et al. (1985) and the federal guidelines (CCREM, 1987) for zinc, copper, cadmium and lead. However, at depth zinc (0.052 mg L^{-1}) and copper (0.005 mg L^{-1}) exceeded both the lake-specific objectives and federal guidelines at some sites while cadmium (0.0003 mg L^{-1}) and lead (0.002 mg L^{-1}) exceeded only the guidelines at some

Table 4-1

Summarized Concentrations of Heavy Metals in Surface Waters of the South Basin of Buttle Lake (Station 0130082). Range of Values Throughout Year with Upper Values Generally Found During Winter Months. Adapted from Deniseger et al. (1988).

	Year	Range	Total No. of Samples
Total Cadmium			
	1980	<0.5-13	6
	1981	0.6	1
	1982	<0.5-0.6	2
	1983	<0.5	5
	1984	<0.5-0.5	7
	1985	<0.5	8
	1986	<0.5	9
	1987	<0.5	5
	1988	<0.5	5
	1989	<0.5	2
	1990[1]	<0.2	1
	Objective[2]	1.3	
	Guideline[3]	0.2	
Total Copper			
	1980	5-30	6
	1981	4-30	5
	1982	4-15	5
	1983	3-9	5
	1984	2-20	8
	1985	<1-7	8
	1986	1-<10	9
	1987	2-10	5
	1988	<1-5	5
	1989	<1-9	6
	1990[1]	2	1
	Objective[2]	2.5	
	Guideline[3]	2	

All values in micrograms L^{-1}

< Denotes below detection limits

[1] Present study

[2] Nordin et al. (1985)

[3] CCREM (1987)

Table 4-1 (Cont'd)

Year	Range	Total No. of Samples
Total Zinc		
1980	110-370	6
1981	100-280	5
1982	30-170	3
1983	18-120	5
1984	10-140	8
1985	30-70	8
1986	20-50	9
1987	20-80	5
1988	11-60	5
1989	12-40	6
1990[1]	22	1
Objective[2]	50	
Guideline[3]	30	
Total Lead		
1980	<1-4	6
1981	<1-4	1
1982	<1-4	2
1983	<1-3	6
1984	<1-2	6
1985	<1-1	5
1986	<1-4	9
1987	<1-9	5
1988	<1-2	4
1989	<1-1	6
1990[1]	<1	1
Objective[2]	5	
Guideline[3]	1	

All values in micrograms L^{-1}
< Denotes below detection limits
1 Present study
2 Nordin et al. (1985)
3 CCREM (1987)

sites (Appendix C). This is a large improvement over historical metal levels and has been followed by a marked recovery of the biota in the lake (Deniseger et al., 1988).

4.2 Sedimentation Rate in the South Basin

The solid-phase chemical compositions described in Section 3.2 clearly indicate that tailings are widespread in the south basin of Buttle Lake, but that at all locations sampled, the deposits are being gradually covered with natural sediments. At every site at which coring was attempted, it appeared that natural sediments were present at the sediment-water interface. This was true even at those locations near the former discharge raft where the tails repeatedly washed out of the core barrel. Given that tailings deposition ceased in July of 1984, the rate of sedimentation of natural deposits can be estimated from the thickness of the organic-carbon-rich layer at each location (Figure 3-8 and Appendix E). In each case the natural sediment veneer is close to 2 cm thick. This layer still contains significant concentrations of tailings (Figure 3-5), which implies that the sediments are being bioturbated to some extent. Indeed, string-like faecal casts were observed on the surface of core BUT 2 suggesting the presence of an active infauna but bioturbation was clearly not intensive. However, with the laminated character of the upper few centimetres at stations BUT 2, 4, and 5 (Frontispiece) any bioturbation will smear the organic carbon profile and mix tailings upward into the surface sediments. Thus, the sedimentation rate in the south basin is at most 4 mm yr^{-1}, and is likely less. This estimate agrees well with the range calculated by Pedersen (1983b) using ^{210}Pb profiles.

4.3 Manganese and Iron Diagenesis

Bacterial oxidation of reactive organic matter in lacustrine sediments proceeds via a series of overlapping electron-transfer reactions. As degradation proceeds, thermodynamically-unstable reduced carbon compounds serve as electron donors and various oxidants act as terminal electron acceptors (see review in Chapter 3 of Rescan, 1989). During oxidation, organic matter will donate electrons to orbitals of lowest available energy level as this produces the greatest free energy gain per unit of organic material oxidized. The reaction sequence proceeds in an order mandated by the net free energy yield, with aerobic oxidation (the highest-yield reaction) preceding (in thermodynamic order) denitrification, manganese and iron oxyhydroxide reduction, sulphate reduction, and methanogenesis (Froelich et al., 1979).

In sediments in mesotrophic or eutrophic lakes, the organic carbon content is usually sufficient to establish anoxic conditions at depths ranging from a few millimetres to one decimetre. The resulting chemical zonation is therefore characterized by a decreasing redox potential with depth and the release to interstitial solution of a number of reaction products. Two such products are dissolved manganese and iron. Because Fe oxyhydroxide reduction commences almost as soon as O_2 has been depleted, the depth at which Fe^{2+} first appears in pore water is a reasonably precise indicator of the sub-bottom oxic-anoxic boundary (Rescan, 1989). MnO_2 reduction and associated addition of Mn^{2+} to pore water occurs at slightly shallower depths, and thus at a slightly higher oxidizing potential. The presence of Fe and Mn oxide phases in near-surface sediments has important implications for the diagenetic behaviour of heavy metals, given that both oxyhydroxides are effective at scavenging metals from solution (Kadko et al., 1987).

Joint comparison of the dissolved and solid-phase Mn distributions (Figure 4-1) indicates that Mn oxides are dissolving within millimetres of the sediment-water interface at all four sites. This is particularly obvious in cores BUT 5 and 6. The dissolved manganese concentration in the upper 5 mm at station BUT 2 is actually higher than in the equivalent sample interval at BUT 6 because of the different scales on the abscissae, but the profile is dominated by the much higher concentrations at depth in the former core. Clearly, there is an additional source of dissolved Mn in the natural sediments penetrated at stations BUT 2, 4 and 5 which is supporting upward diffusion of Mn toward the surface. Presumably, the source is the Mn oxyhydroxides which were buried by the tailings in the past and are still dissolving. Indeed, solid-phase Mn concentrations are high in the natural sediments underlying the tailings (Figure 4-1), although the Mn-rich zone at depth in each case is thicker than would be expected if the sediment-pore water system had been in steady-state diagenetic equilibrium prior to the commencement of tailings discharge. Why this should be the case is not known.

The pore water Mn profiles clearly are not in steady-state equilibrium with the solid phase distributions of the element. This is most obvious in core BUT 5 where Mn is diffusing upward from near the base of the core, as well as upward and downward from the maximum concentration in the top centimetre (Figure 4-1). Given a bulk diffusion coefficient (corrected for porosity and tortuosity) for Mn^{2+} at 6°C of ~3.5 x 10^{-6} cm^{2-1} (calculated from the data in Li and Gregory, 1974), it would take about 2 years for Mn^{2+} to diffuse downward 10 cm (from the near-surface maximum to about the mid-depth minimum in BUT 5). This is of the same order as the length of time since the

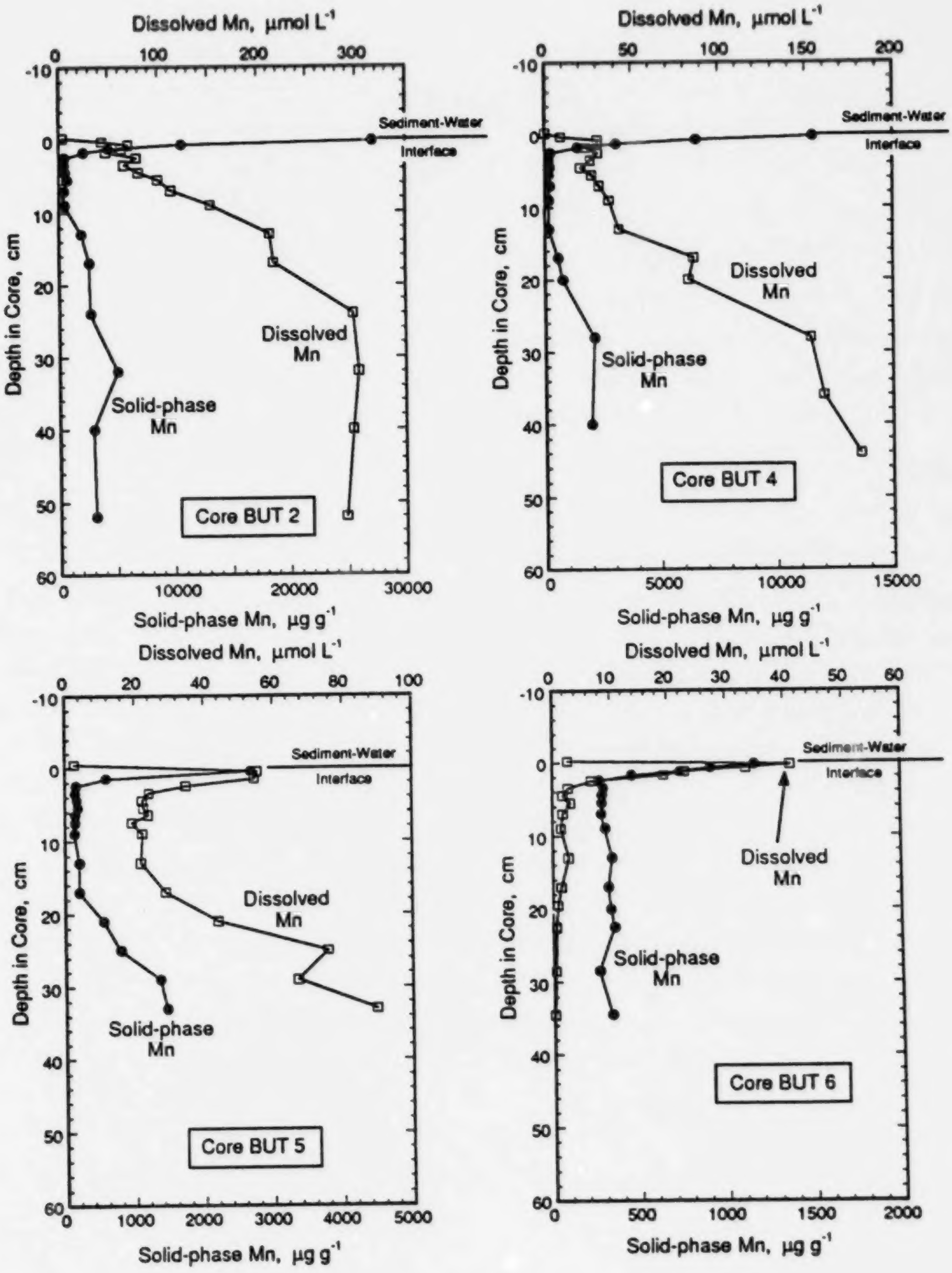

Figure 4-1 Dissolved and solid-phase Mn concentration profiles in cores from the south basin of Buttle Lake. Note the variable scales on the abscissae.

depositional regime markedly and suddenly changed in the south basin (i.e. when the tailings discharge ceased in 1984). Thus, it is not surprising that diffusion has not yet smoothed the pore water profiles. There has been insufficient time since the tailings deposition ceased for a new diagenetic equilibrium to become established. This observation applies to all four cores, and the same reasoning applies to the heavy metal distributions as discussed below.

The near-surface solid-phase and dissolved Mn distributions indicate that Mn oxyhydroxides must be precipitating at or very near the sediment-water interface at all sites. Thus, at least part of the solid-phase Mn maximum at the surface in each core can be attributed to diagenetic ingrowth as Mn oxides are buried just below the interface where they dissolve and support an upward diffusive flux of dissolved Mn. This, in turn, fosters the diagenetic accumulation of the element at the sediment surface.

In addition, detrital Mn and Fe oxyhydroxides must also be contributing significantly to the surface enrichments of these elements seen at the coring sites. Both phases are ubiquitous components of fluvial detritus typically occurring as coatings on particles (see Chapter 3 in Rescan, 1989, for a review).

As is the case for manganese, dissolved iron is added to pore water at shallow depths at all sites. At station BUT 6, for example, reductive dissolution of Fe oxyhydroxides must be occurring within 15 mm of the sediment-water interface (Figure 4-2); in BUT 2, 4 and 5, the dissolved Fe distributions indicate significant addition of Fe^{2+} to pore water at about 20 mm depth. Above this horizon, upward concavity in the dissolved Fe profiles indicates consumption from solution reflecting oxidation and precipitation of upward-diffusing Fe^{2+}. This is presumably where the metal first encounters O_2 diffusing downward from the overlying lake water. Because Fe oxyhydroxides dissolve at a lower redox potential than Mn oxides, and because Fe^{2+} oxidizes much more rapidly than Mn^{2+} at ambient pH, the dissolved Mn and Fe distributions show a slight spatial separation at all sampling locations. Mn^{2+} appears at high concentrations in the four cores some 5 to 10 mm above the depths where the dissolved Fe content jumps suddenly upward (Figure 3-15 and Appendix G). This difference may be responsible for the occurrence of the solid-phase Fe peak at 1.5 cm depth in cores BUT 2 and 4, just below its counterpart for Mn (compare Figures 4-1 and 4-2). The peak is interpreted to represent ingrowth of authigenically precipitated FeOOH, as a result of upward diffusion of Fe^{2+} and precipitation near the surface.

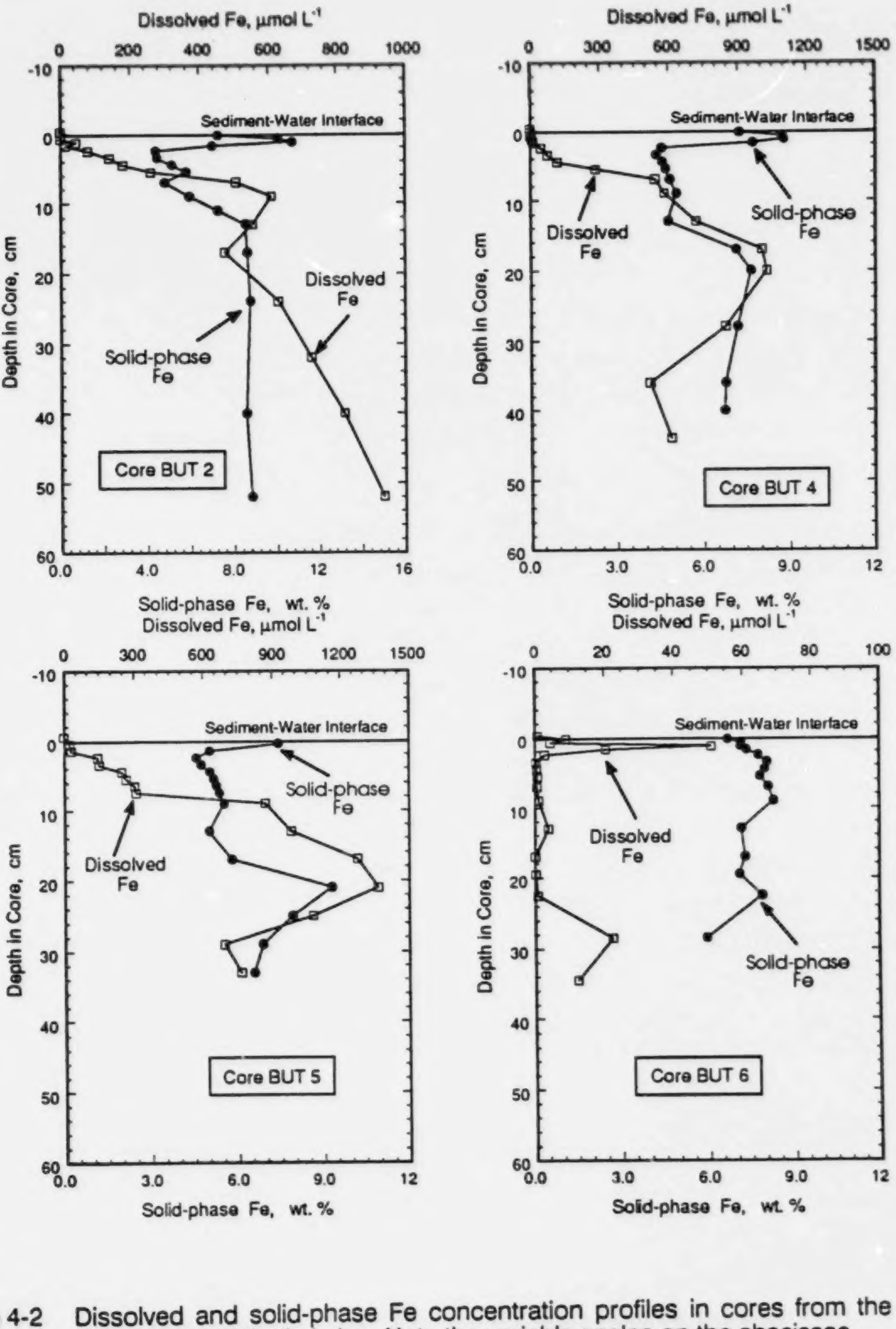

Figure 4-2 Dissolved and solid-phase Fe concentration profiles in cores from the south basin of Buttle Lake. Note the variable scales on the abscissae.

4.4 Zn, Cu, Pb and Cd Diagenesis

In the upper two decimetres of the "rapidly-accumulating pure tailings" facies represented by core BUT 6, dissolved Zn, Cu, Pb and Cd concentrations are extremely low (Figures 3-13 and 3-14, and Appendix G). Zn and Cd levels are lower than in the overlying lake water, while Pb and Cu values are of the same order as concentrations in south basin deep water. These distributions indicate that there can be no efflux of dissolved metals from the submerged tailings to the overlying water at this site.

Relatively high concentrations of Zn, Cu, Pb, Cd and Fe do occur in pore waters in the lower decimetre of core BUT 6, suggesting that release from solid phases is occurring at depth at this location. Why this should be the case is not clear. Certainly, there are no obvious changes in the elemental or mineralogic composition of the tailings in the lower half of this core, other than a marked depletion of the organic carbon content in the lowermost 20 cm (Appendix E), which could indicate an overall solid-phase compositional control on the pore water distributions.

At the other three sampling locations, where the tailings accumulated relatively slowly, several factors appear to control the dissolved heavy metals distributions. Each will be discussed in turn. First, sulphate reduction should be occurring at relatively shallow depths, considering that dissolution of Mn and Fe oxides occurs near the sediment-water interface. Methane is also abundant in the natural sediments below the tailings layers, indicating strongly reducing conditions at depth in the cores. The concomitant production of H_2S, as sulphate is reduced, should foster the precipitation of sulphide minerals, particularly FeS and/or FeS_2; where H_2S is present (in solution largely as HS^-), the trace heavy metals should also precipitate, either as discrete phases (CuS, ZnS, CdS and PbS) or in solid solution with the authigenic iron sulphides. Such precipitation has been shown to occur naturally within the top 20 mm of the sediments in some lakes in eastern Canada (Carignan and Tessier, 1985; Carignan and Nriagu, 1985). Thus, the low concentrations of dissolved heavy metals in the natural sediment layers in the three cores are attributed to precipitation of authigenic sulphide minerals. Mn is unlikely to precipitate as a sulphide phase because MnS is relatively soluble (Jacobs and Emerson, 1982). Indeed, unlike the other metals, there is no indication of removal of dissolved Mn from solution at depth in the cores. In contrast to MnS, FeS is highly insoluble; the persistently-high dissolved iron concentrations at depth are thus attributed to a lack of dissolved sulphide, which reflects the low concentration of SO_4^{2-} ion available for bacterially-mediated reduction in most lake waters.

Second, in all three cores there are discrete zones of metal release which are defined by the distributions of all four heavy metals, as discussed in Section 3.3. Sampling artifacts and/or contamination can be ruled out as a source of these irregularities in the profiles, given the consistent distributions of the four metals, the consistently extremely low concentrations in pore waters extracted from the natural sediments underlying the tailings, and the smoothness of the iron and manganese profiles. The one exception may be the high Zn concentration at 9 cm depth in BUT 5, which is not matched by commensurate increases in dissolved Cu, Pb and Cd. Non-steady-state depositional effects in south basin sediments are expected to be reflected by discontinuities in the pore water profiles, particularly relative to the distribution of diagenetically recycled phases (e.g. Mn and Fe oxides) as discussed in Section 4.3. The thin dissolved-metal-rich horizons seen in cores BUT 2, 4, and 5 therefore may have been influenced by non-steady-state effects. For example, the cessation of tailings discharge would have increased the exposure time of tailings at the sediment surface to bottom water oxygen for some period until an anoxic veneer of natural sediments had accumulated. During this period (from July 1984 to some later date) oxidation of the tailings could have occurred, with concomitant release of trace heavy metals from the more soluble oxidized alteration products. It is possible that the high concentrations of Zn, Cu, Pb and Cd seen between 4 and 10 cm depth in BUT 2, 4 and 5 are a waning reflection of this transition period, although there are no visual signs of oxidation of the tailings in this zone. In any event, past oxidation cannot be the sole explanation for the distributions.

The fact that the dissolved metal-rich zones are so thin implies that they are being dynamically maintained by zones of production and consumption. Otherwise, diffusion operating over time-scales of a few years would have at least partly smoothed the discontinuities seen in the present data. The precipitation (and sedimentation) of Fe and Mn oxyhydroxides in the near-surface sediments in the south basin can be expected to provide an adsorbent veil for upwardly diffusing trace metals because both oxide phases have a high scavenging capacity for a range of metallic cations and anions (see Chapter 3 in Rescan, 1989). Indeed, adsorption of Zn from pore water onto FeOOH in the upper 40 to 60 mm at sites BUT 2 and 4 (and less obviously in BUT 5) is implied by the spatial correlation between the dissolved Fe and Zn profiles near the sediment-water interface (Figure 4-3). Negative curvature (i.e. upward concavity) can be seen in

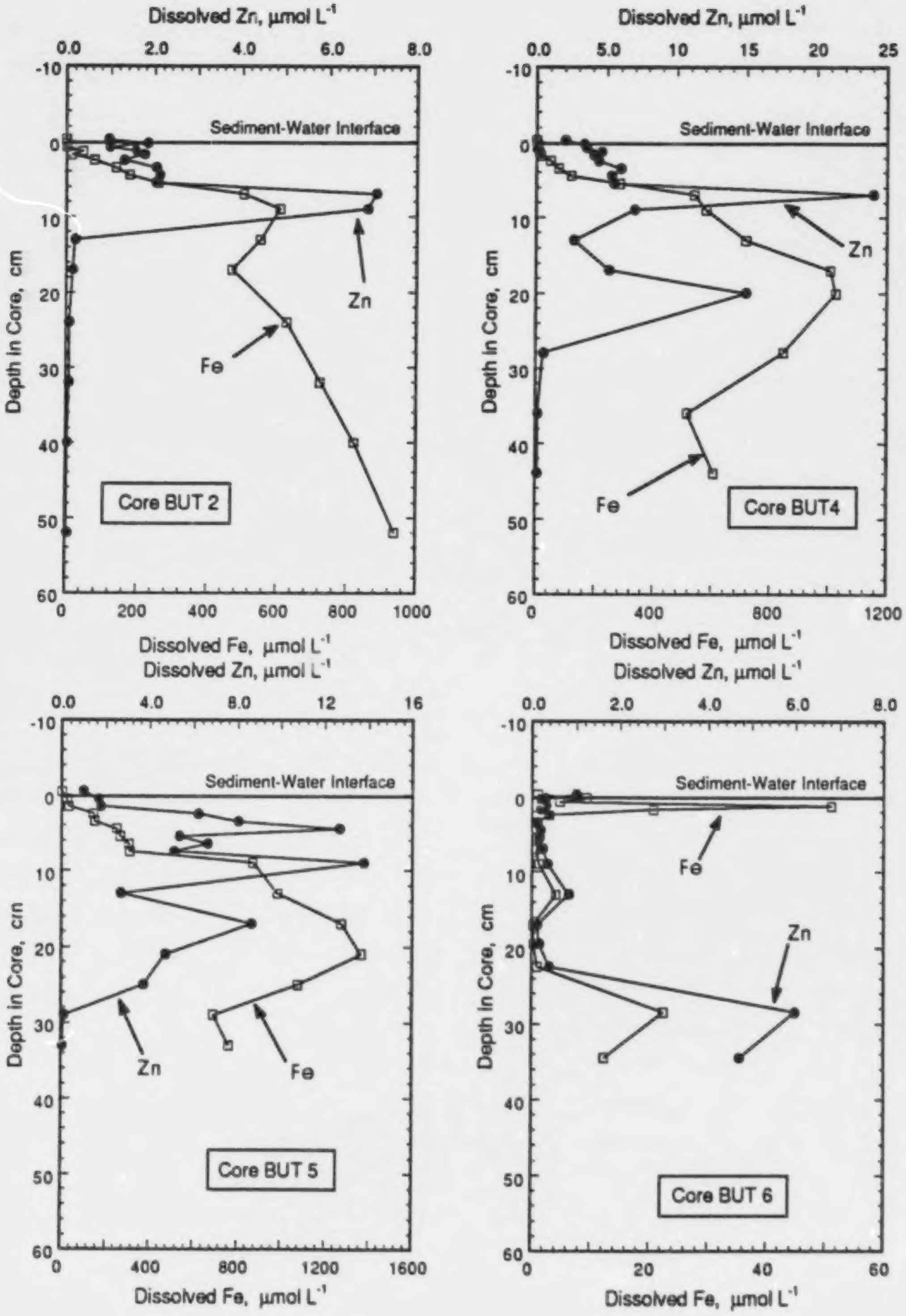

Figure 4-3 Dissolved Zn and Fe profiles in pore waters extracted from cores collected in the south basin of Buttle Lake. Note the variable scales on the abscissae.

the profiles of both elements in the top 6 cm at all three sites, indicating removal from solution. Presumably, Fe is being freshly precipitated as an oxyhydroxide phase and Zn is being scavenged by this authigenic product. The congruent Cu, Pb and Cd distributions imply that these metals are being similarly scavenged. The corollary of this model is that as FeOOH is subsequently buried and reduced, the trace metals will be recycled to interstitial solution and will diffuse upward to be rescavenged, or downward to be fixed in (presumably) sulphide phases in the underlying sulphate reduction zone. However, this simple model cannot explain why double maxima are seen in the trace metal profiles in BUT 4 and 5 (Figure 3-14).

It is well known that dissolved humic acids precipitate at low pH (e.g. Sholkovitz, 1976). Such precipitates were noted in several of the acidified pore water samples during analysis for dissolved metals (see Appendix G). Dissolved humic acids have a high complexing capacity for trace metals (see Rescan, 1989, p. 3-20), and where such compounds are abundant in solution, they can promote high concentrations of dissolved metals because they have a higher affinity for metallic cations than many inorganic solid-phase ligands (Stumm and Morgan, 1981). It is thus noteworthy that the highest dissolved heavy metal contents occur in the same samples as the humic acid precipitates (Appendix G). Why the DOC (dissolved organic carbon) content should be high in these samples is not clear - the sedimentary organic C and total N profiles (Figure 3-8) show no relationship with the occurrence of the organic precipitates, and there is similarly no correlation with variations in the composition of the organic material as indicated by the C/N ratio profiles (Figure 3-9). Nevertheless, it appears that the discrete zones where the dissolved metal concentrations are high are at least partly related to the occurrence of high DOC levels in the same horizons. An important implication of this association is that diffusion coefficients of metal-organic complexes are significantly smaller than for uncomplexed ions; thus the presence of dissolved humic compounds in sediments will act to lessen diffusive fluxes of metals.

Finally, the dissolved Cd concentration is higher in the uppermost 5 mm at stations BUT 2 and 4 than in the supernatant water or pore water in the immediately underlying sediments (Figure 3-14). We suggest that such distributions reflect the delivery of Cd to the sediment surface by settling organic matter of planktonic origin, and its subsequent release to solution as the organic material is metabolized. Support for this cycle is offered by the observation that some metals, such as Cu, are extracted by algae from the epilimnion of British lakes and carried to the sediment-water interface where they are released back into the hypolimnion (Hamilton-Taylor et al., 1984). Similarly, Gobeil et al. (1987) reported that Cd is released to solution at the interface in shallow marine sediments in the Laurentian Trough, presumably as a result of degradation of recently-settled organic material. The metal diffuses both upward and downward from the surface maximum, consumption at depth being due either to adsorption onto freshly-precipitated Mn oxides or precipitation of CdS. Such considerations apply equally to the sediments in BUT 2 and 4.

4.5 Benthic Fluxes

The concentrations of metals measured in the supernatant waters at each of the four core sites are very close to the values measured by Waste Management Branch personnel during the last seven months of 1989 (L. Erickson, pers. comm.). This comparison suggests that the measured dissolved metals concentrations in the core top water reasonably represent the metal levels in bottom water in the south basin. In order to produce reasonable estimates of benthic influxes or effluxes of metals to or from the sediments, we have chosen to use the mean of the concentrations of each metal measured in the four supernatant water samples (the slightly high Zn value in the supernatant for BUT 4 was omitted from the calculation of the mean for Zn). These average values are taken as being representative of the metal levels in the bottom water of the south basin.

Diffusive fluxes across the sediment-water interface are calculated from Fick's first law:

$$J = -\ \phi(K_c/F)(\partial C/\partial x)$$

where ϕ is the porosity (assumed here to be 1, since the water content in the organic-rich natural sediments was very high; the flux will be only slightly overestimated by the adoption of 100% porosity). K_c is the diffusion coefficient for each metal (from Li and Gregory, 1974) corrected for estimated *in situ* temperature (6 °C); the metals are presumed to occur largely as divalent ions - no allowance is made for complexation in the calculations. The coefficients are thus 4×10^{-6} cm^2 s^{-1} for Zn, Cu and Cd, and 5.5×10^{-6} cm^2 s^{-1} for Pb. $\partial C/\partial x$ is the concentration gradient calculated as the concentration difference between the bottom water (2.5 mm above the interface) and the mean dissolved metal concentration in the top cm of the sediments (taken to be at a depth of 5 mm; thus ∂x is 0.75 cm). F is the formation factor (Manheim, 1970) which takes into account the tortuous diffusion path of an ion in wet sediments. Given the high water content of the uppermost sediments at each core site, we estimate the formation factor to be only slightly greater than unity; thus F is taken to be 1.1. No corrections are applied here for the possible electrical coupling of the divalent metal ions to the fluxes of major ions (see Lasaga, 1979), since the latter are unknown. In eastern Canadian lakes, Carignan and Tessier (1985) found that correcting for the coupling effect required a relatively small adjustment in the calculated flux for Zn^{2+} (about +10% in one lake, and -7% in another). Since we have no major ion data, we have chosen to ignore this small potential effect on our calculated fluxes.

The flux calculations are listed in Table 4-2. Several points are noteworthy. First, Zn and Cd are diffusing from the overlying lake water into the tailings at site BUT 6. This is a reflection of the extremely low pore water metal concentrations in this facies and is similar to the result reported by Pedersen (1983a) for the rapidly accumulating tailings.

Second, Cd fluxes in general are very low; those out of the sediments are very similar to fluxes measured directly by Westerlund et al. (1986) in unpolluted Swedish coastal marine sediments (about 0.4 nmol cm^{-2} yr^{-1}) and effluxes from unpolluted sediments in the Laurentian Trough (0.1 to 0.3 nmol cm^{-2} yr^{-1}) estimated by Gobeil et al. (1987).

Third, Pb is diffusing out of the sediments at stations BUT 4, 5, and 6 but at an extremely low rate, on the same order as Cd. As far as we know, these are the first reported Pb fluxes from lake sediments, so we are unable to compare these results with data from other studies; however measurements of Pb in pore water made by Westerlund et al. (1986) in coastal marine sediments imply fluxes somewhat lower in magnitude than the low levels reported here. Pb appears to be diffusing from the lake water into the deposits at station BUT 2.

Fourth, the indicated benthic efflux of Cu at each location is also very low and is of the same order as effluxes measured by Westerlund et al. (1986) in Swedish shallow marine sediments, Pedersen (1985) in Holberg Inlet on Vancouver Island (0.4 nmol cm^{-2} yr^{-1}) and by Heggie (1983) in unpolluted sediments in Resurrection Bay, Alaska (3 nmol cm^{-2} yr^{-1}). Finally, Zn effluxes at stations BUT 2, 4 and 5 range from 7 to 38 nmol cm^{-2} yr^{-1}, higher than those for the other metals. These levels are comparable to the natural flux emanating from unpolluted Swedish coastal sediments measured directly by Westerlund et al. (1986). To put the potential impact of this flux in context, we have integrated the maximum flux (38 nmol cm^{-2} yr^{-1}) over the area of the bottom of the south basin

Table 4-2

Calculated benthic fluxes of selected metals from sediments in the south basin of Buttle Lake. Concentration gradients ($\partial C/\partial x$) are all in units of 10^{-3} μmol cm^{-4} of selected metals from sediments in the south basin of Buttle Lake. Fluxes (J) are all in units of nmol cm^{-1} yr^{-1}.

		Station			
Metal		BUT 2	BUT 4	BUT 5	BUT 6
Zn	$\partial C/\partial x$	0.6	3.3	1.0	-1.0
	J	-7	-38	-11	**+11**
Cu	$\partial C/\partial x$	0.17	0.21	0.08	0.002
	J	-1.8	-2.5	-0.9	-0.3
Pb	$\partial C/\partial x$	-0.001	0.009	0.023	-3.0
	J	**+0.2**	-2	-0.4	-0.8
Cd	$\partial C/\partial x$	0.006	0.006	-0.003	-0.0035
	J	-0.7	-0.7	**+0.4**	**+0.4**

A negative sign indicates that the metal concentration in pore water is less than in the overlying lake water.
A negative sign indicates a flux out of the sediments.
Fluxes into the sediments are highlighted.

assumed to be covered by deposits chemically similar to those cored at stations BUT 2, 4 and 5. Such deposits are roughly estimated to cover 2 km^2 (4 km by 0.5 km) of the floor of the south basin. In one year (approximately the residence time for water in the south basin), the total release of Zn to bottom water would be about 760 mol, or about 50 kg. This would be buffered to some extent by the uptake of Zn by deposits similar to those at BUT 6. Fifty kg of Zn added to the lower 50 m of south basin water (a volume of about 0.3×10^{12} L) would increase the concentration by only 0.003 nmol L^{-1} (about 0.2 parts per trillion). This number is, of course, poorly constrained given the crude assumptions used in the calculations, but it is probably of the right order. Clearly, the benthic efflux of Zn implied by the pore water profiles at stations BUT 2, 4 and 5 is so small as to have an immeasurable impact on water quality.

5 - Conclusions

5.0 CONCLUSIONS

1. Zn-, Cu- and Pb-rich tailings are widely distributed across the south basin of Buttle Lake, and are now being covered with a veneer of organic-rich sediments at a rate on the order of 4 mm yr^{-1} at all sites. High solid-phase metal concentrations are still observed in the upper 5 mm at all four core locations, which presumably reflects upward mixing of tailings by burrowing infauna.

2. Profiles of dissolved and solid-phase Mn and Fe indicate that at all locations, the deposits are anoxic below depths of about two or three cm.

3. Dissolved metals levels in pore waters in methane-bearing natural sediments underlying the tailings are extremely low, probably due to precipitation of authigenic sulphide minerals. High-resolution profiles in the upper two decimetres indicate that dissolved Zn, Pb, Cu and Cd concentrations are very low in tailings near the site of the former discharge point. In distal deposits, where the tailings accumulated more slowly and have formed a layer one to two decimetres thick, one or two thin and discrete zones of relatively high dissolved metals levels are observed. The control on these distributions is not clear, but the high metal values are associated with high dissolved organic carbon contents in the same horizons, suggesting that complexation by organic ligands may be important in keeping metals in solution.

4. A spatial correlation between increases in dissolved Fe in the upper several cm of the cores and increases of Zn, Cu, Pb and Cd in pore waters at approximately the same depths implies that dissolution of Fe oxyhydroxides may be releasing heavy metals to interstitial waters at shallow depths. The corollary of such an association is that freshly-precipitated FeOOH, which forms in the upper portion of the sediment column where upward-diffusing dissolved Fe reacts with downward-diffusing O_2, may be scavenging heavy metals from solution. Upward concavity seen in the uppermost several cm of the pore water metal profiles supports this suggestion. This implies that the Fe and Mn oxide-rich veneer at the core top is providing an absorbent veil which reduces upward diffusion of dissolved heavy metals from enriched zones below.

5. Comparison of the pore water metals profiles with the concentration of dissolved metals in south basin deep water indicates the metals must be diffusing into the tailings at the site near the former discharge raft. At the other locations there are very small effluxes of metals in most cases. Benthic flux calculations indicate that the amounts of Cu, Cd and Pb which can be diffusing out of the bottom are on the same order as is typically observed in unpolluted natural sediments. The largest efflux is of Zn; simple calculations indicate that if integrated over the appropriate area of the floor of the south basin, the Zn flux could increase the steady-state Zn content in deep water by less than 0.2 ng L^{-1} (<0.2 parts per trillion).

6. Based on the high-resolution interstitial water data presented in this report, it is clear that the now-buried tailings in the south basin of Buttle Lake are having a negligible impact on water quality in this basin.

References

REFERENCES

APHA. 1985. Standard methods for the examination of water and wastewater. American Public Health Association. Washington, D.C.

Abbey, F. 1983. Studies in Standard Samples of silicate rocks and minerals 1969-1982. Geological Survey of Canada. Paper 83-15. 114 pp.

Aller, R.C. 1983. The importance of the diffusive permeability of animal burrow linings in determining marine sediment chemistry. Jour. Mar. Res. 41, 299-322.

Bohn, A. 1982. Written communication.

Bray, J.T, D.P. Bricker and B.N. Troup. 1973. Phosphate in interstitial waters of anoxic sediments: oxidation effects during sampling procedure. Science 180, 1362-1364.

B.C. Research. 1980. Literature review and mine tailing sampling at the bottom of Buttle Lake. Prepared for Western Mines Ltd. Prepared by B.C. Research, Vancouver, B.C.

Carignan, R. and J.O Nriagu. 1985. Trace metal deposition and mobility in the sediments of two lakes near Sudbury, Ontario. Geochim. Cosmochim. Acta 49, 1753-1764.

Carignan, R. and A. Tessier. 1985. Zinc deposition in acid lakes: the role of diffusion. Science 228, 1524-1526.

CCREM. 1987. Canadian water quality guidelines. Prepared by Task Force on Water Quality Guidelines of the Canadian council of Resource and Environment Ministers, March 1987.

Deniseger, J., L.J. Erickson, A. Austin, M. Roch and M.J.R. Clark. 1988. The effects of decreasing heavy metal concentrations on the biota of Buttle Lake, Vancouver Island, British Columbia. Unpublished manuscript, Waste Management Branch, Ministry of Environment and Parks, Province of British Columbia, 32 pp.

Eccles, A.G. 1977. Pollution control at Western Mines' Myra Falls operation. CIMM Bull. 70, 141-147.

Froelich, P.N., G.P. Klinkhammer, M.L. Bender, N.A. Luedtke, G.R. Heath, D. Cullen, P. Dauphin, D. Hammond, B. Hartman, and V. Maynard. 1979. Early oxidation of organic matter in pelagic sediments of the eastern equatorial Atlantic: suboxic diagenesis. Geochim. Comochim. Acta 43, 1075-1090.

Gillie, R. 1982. Turbidity and bottom sediment surveys of Buttle and Upper Campbell Lakes. Prepared for Waste Management Branch, Ministry of Environment. Dobrocky Seatech Limited, Sidney, B.C. 76 p.

Gobeil, C., N. Silverberg, B. Sundby and D. Cossa. 1987. Cadmium diagenesis in Laurentian Trough sediments. Geochim. cosmochim. Acta 51, 589-596.

Hamilton-Taylor, J., M. Willis and C.S. Reynolds. 1984. Depositional fluxes of metals and phytoplankton in Windermere as measured by sediment traps. Limnol. Oceanogr. 29, 695-710.

Harvey, P.K. and B.P. Atkin. 1982. The estimation of mass absorption coefficients by Compton scattering: extensions to the use of RhKa Compton radiation and intensity ratios. Am. Mineral. 67, 534-537.

Heggie, D.T. 1983. Copper in the Resurrection Fjord, Alaska. Est. Cst. and Shelf Sci. 17, 613-635.

Jacobs, L.A. and S. Emerson. 1982. Trace metal solubility in an anoxic fjord. Earth Planet. Sci Lett. 60, 237-252.

Kadko, D., J.K. Cochran and M. Lyle. 1987. The effect of bioturbation and adsorption gradients on solid and dissolved radium profiles in sediments from around the eastern Equatorial Pacific. Jour. Geophys. Res. 89, 6567-6570.

Lasaga, A.C. 1979. The treatment of multi-component diffusion and ion pairs in diagenetic fluxes. Am. J. Sci. 279, 324-346.

Li, Y.-H. and S. Gregory. 1974. Diffusion of ions in seawater and in deep-sea sediments. Geochim. Cosmochim. Acta 38, 703-714.

Manheim, F.T. 1970. The diffusion of ions in unconsolidated sediments. Earth. Planet. Sci. Lett. 9, 307-309.

Nordin, R.N., C.J.P. McKean, I.T. Boydd, M.J.R. Clark, M.R. Roch and J. Deniseger. Effects of dissolved metals on the aquatic biota of the lakes of the Campbell River watershed. British Columbia Ministry of Environment, Victoria, B.C. 235 pp.

Norrish, K. and J.T. Hutton. 1969. An accurate X-ray spectrographic method for the analysis of a wide range of geological samples. Geochim. Cosmochim. Acta 33, 431-453.

Pedersen, T.F. 1982. Dissolved interstitial Zn, Cd and Cu in mine tailing in Buttle Lake. Unpublished report prepared for Westmin Resources Ltd. 17 pp.

Pedersen, T.F. 1983a. Dissolved heavy metals in a lacustrine mine tailings deposit-Buttle Lake, British Columbia. Mar. Poll. Bull. 14, 249-254.

Pedersen, T.F. 1983b. Rate of accumulation of natural sediments in the south basin of Buttle Lake, B.C. Unpublished Report prepared for Westmin Resources Ltd.

Pedersen, T.F. 1984. Interstitial water metabolite chemistry in a marine mine tailings deposit, Rupert Inlet, B.C. J. Earth Sci. 21; 1-9.

Pedersen, T.F. 1985. Early diagenesis of copper and molybdenum in mine tailings and natural sediments in Rupert and Holbey inlets, British Columbia. Can. J. Earth Sci. 22; 1474-1484.

Pedersen, T.F. and A.J. Losher. 1988. Diagenetic processes in aquatic mine tailings deposits in British Columbia. In: Chemistry and Biology of Solid Waste (W. Salomons and U. Forstner, eds.), Springer-Verlag, Berlin. pp. 238-258.

Pedersen, T.F., S.J. Malcolm and E.R. Sholkovitz. 1985. A lightweight gravity corer for undisturbed sampling of soft sediments. Can. J. Earth Sci. 22; 133-135.

Rescan. 1989. Subaqueous disposal of mine tailings. Report to the Acid Mine Drainage Task Force. Prepared for B.C. Ministry of Energy, Mines and Petroleum Resources. Prepared by Rescan Environmental Services Ltd.

Sholkovitz, E.R. 1976. Flocculation of dissolved organic and inorganic matter during mixing of river water and seawater. Geochim. Cosmochim. Acta. 40, 831-845.

Stumm, W. and J.J. Morgan. 1981. Aquatic Chemistry, Second Edition. John Wiley and Sons, New York. 780 pp.

Westerlund, S.F.G., L.G. Anderson, P.O.J. Hall, A. Iverfeld, M.M. van der Loeff and B. Sundby. 1986. Benthic fluxes of cadmium, copper, nickel, zinc and lead in the coastal environment. Geochim. Cosmochim. Acta 50, 1921-1930.

Detailed Core Descriptions

APPENDIX A: DETAILED CORE DESCRIPTIONS

CORE BUT 2: North end of South Basin

87 m water depth, 61.5 total length; excellent, undisturbed interface; entry speed <0.2 m sec^{-1}; clear supernatant; capped and hand-held back to minesite.

Log Description:

0-3 mm: Medium brown fluff layer, undisturbed, some organic fragments visible on surface, along with thin string-like faecal casts. Very fine-grained, uncompacted, non-cohesive.

3-4 mm: pale brown; otherwise similar.

4-9 mm: chocolate brown; otherwise similar.

9-16 mm: pale brown; same material but slightly more compact.

16-18 mm: rusty-brown; similar to 9-16 mm interval.

18-21 mm: fluffy layer, poorly compacted, olive grey colour.

21-26 mm: very pale brown, similar to 9-16 mm interval.

26-29 mm: pale greyish brown.

29-70 mm: very fine-grained tailings evident, laminated on a variable 1-3 mm interval. 1 mm thick rusty layers at 40 mm and 50 mm. Occasional brown specks (organic matter?) disseminated throughout.

70-140 mm: more massive tailings; silty-gray, non-laminated.

140-615 mm (end): natural silt, pale olive gray-green. Organic fragments throughout. Lower 400 mm of core show signs of CH_4 degassing (bubbles formed *in situ*).

CORE BUT 4: Eastern edge of axial trough, central South Basin

41 m water depth; 49 cm total length; pristine interface.

Log Description:

0-5 mm: fluffy, floc-like surface layer - medium dark brown.

5-15 mm: paler, slightly orange brown, uncompacted, very fine-grained.

15-20 mm: transitional to gray, unoxidized very fine-grained tailings.

20-280 mm: tailings, upper 150 mm of which are laminated on 1-2 mm scale. Occasional dark specks, presumably organic matter.

250-280 mm: more massive, dark steely-gray unlaminated tailings.

280-490 mm: natural sediments, dark olive-green silts, abundant organic fragments, evidence of CH_4 degassing.

CORE BUT 5: South end of axial trough, north of mouth of Myra Creek

39 m water depth; 46 cm total length; slightly disturbed interface (domed top); probably about 5 mm lost around edges (corer entered slightly too quickly). Little resuspension evident; supernatant generally clear - some resuspended floc/fluff.

Log Description:

0-5 mm: domed, medium chocolate brown, uncompacted, fine-grained, organic fragments evident.

5-20 mm: orange-brown, same material.

20-300 mm: tailings, laminated throughout (particularly to 150 mm) on a 1-5 mm scale; occasional brownish layers (< 1 mm thick) within tailings.

300-460 mm: natural sediments; homogeneous medium olive-green silt; organic fragments throughout; CH_4 bubbles formed before processing.

Overall: very similar to BUT 4. About 5 cm lost from bottom of core when inserting extrusion piston prior to processing.

CORE BUT 6: Southwest end of axial trough, near site of former tailings discharge raft

42 m water depth; 45.5 cm total length. Plastic core catcher used which disturbed the interface (~top 1 cm).

Log Description:

0-12 mm: mixture of silty (to fine sand?) tailings and natural sediments, overlain by ~3 cm of gray water with suspended extremely fine tailings particles (essentially not settling). This layer was undoubtedly disturbed.

12-450 mm: essentially featureless, homogeneous gray silt-to-fine-sand-sized tailings. Fresh pyrite clearly visible. Note: tailings throughout the core looked very fresh - no signs of oxidation,

Analytical Methods and Quality Control Data

APPENDIX B: ANALYTICAL METHODS AND QUALITY CONTROL DATA

Graphite Furnace Atomic Absorption Analysis

Dissolved metal concentrations in pore waters were determined by direct-injection graphite-furnace atomic absorption spectrophotometry using a Varian SpectrAA 300 spectrophotometer with Zeeman background correction and a PSD 96 autosampler. All determinations were conducted using pyrolitic L'Vov platforms using peak area measurements and operating conditions adapted from those recommended by the manufacturer.

Standards were prepared by diluting 1000 ppm standard solutions with 1% twice-quartz-distilled HNO_3 in distilled deionized water. Where pore water metal concentrations were outside the linear calibration range, samples were diluted with the same 1% HNO_3.

To check the accuracy of the analyses, two pore water samples with very different metal levels were reanalyzed on different days using both the standard calibration curves method and standard additions. The results are presented in Table B-1. The concentrations determined by both methods are in good agreement. Also shown in the table are analytical precision estimates and the detection limit for each metal, defined in this study as six times the standard deviation of the blank.

X-Ray Fluorescence Analysis

Following freeze-drying and grinding of the sediment samples to fine powders in a tungsten carbide disc mill, major and minor element concentrations were respectively measured on cast glass and pressed powder discs, using an automated Philips PW 1400 X-ray fluorescence spectrometer equipped with a Rh target anode. Glass discs were prepared using a slight modification of the method of Norrish and Hutton (1970), which eliminates the need to apply specific corrections for matrix absorption effects. For minor elements, a method similar to that described by Harvey and Atkin (1982) was used. The samples were prepared by forming a mixture of 4 g sample and 0.5 g finely-divided wax (Hoechst Wax C) into 32-mm diameter discs in a hydraulic press. Calibration for both sets of measurements was provided by a wide range of international

Table B-1

Quality Control Data for GFAAS Measurement of Dissolved Metal Concentrations in Buttle Lake Pore Waters

Sample (Method)	Mn	Fe	Cu	Zn	Cd	Pb
M1 (normal), Day 1	246	8.8	2.6	62.6	0.47	0.32
M1 (normal), Day 2	253	9.8	2.3	57.2	0.43	0.31
%R.S.D.	2.0	7.6	8.7	6.4	6.6	2.2
M1 (std. additions)	250	10.4	2.1	66.8	0.51	0.35
M11 (normal), Day 1	8400	34000	281	480	0.22	262
M11 (normal), Day 2	8940	31700	281	485	0.26	262
%R.S.D.	4.4	5.0	0	0.7	6.6	0
M11 (std. additions)	9260	28850	261	570	0.24	267
Detection limit	0.25	2.7	0.53	0.077	0.035	0.3

All measurements are reported in mg L^{-1}
Normal = measurement by comparison to the linear calibration curve
R.S.D. = relative standard deviation

geochemical reference standards, with discs prepared in the appropriate way, and using the element concentrations recommended by Abbey (1983). Analytical precision can be estimated for major elements by comparing the duplicate discs made for the top two samples from core BUT 4 (Table A). Accuracy was assessed by randomly including several geochemical reference samples as unknowns in the analytical run. The results of these measurements are listed in Table B-2. As can be seen the accuracy of the major element measurements is excellent.

For the minor elements, precision varies depending on the concentrations of the elements, and becomes poor as the detection limit is approached. Detection limits for the elements measured are on the order of 10 mg g^{-1}; measured concentrations near this level are precise only to within 50% relative standard deviation. For the concentrations typically encountered in tailings-free sediments, precision is typically better than + 5% (1σ, r.s.d.). In this study, only the Co and Ni contents approach the XRF detection limit;

Table B-2

XRF Major Element Quality Control Data, Comparing Concentrations Determined for Geochemical Reference Standards in this Study (m), with Concentrations Recommended (r) by Abbey (1983)

Standard		Fe	Ti	Ca	K	Si	Al	Mg	P	Na
NIMG	(m)	1.38	0.06	0.56	3.12	35.37	6.51	0.01	0.00	1.25
	(r)	1.41	0.05	0.56	3.19	35.35	6.39	0.04	0.01	1.25
AGV1	(m)	4.78	0.63	3.53	1.83	27.94	8.74	0.92	0.22	1.59
	(r)	4.76	0.64	3.53	1.87	27.83	9.09	0.92	0.22	1.60
W2	(m)	7.52	0.64	7.71	0.42	24.15	7.70	3.80	0.06	0.83
	(r)	7.60	0.64	7.79	0.40	24.66	8.19	3.85	0.06	0.82
NIMS	(m)	1.04	0.01	0.49	10.01	31.82	9.56	0.26	0.06	0.14
	(r)	0.98	0.02	0.49	9.81	29.71	9.17	0.28	0.05	0.16
G2	(m)	1.83	0.31	1.37	2.77	32.16	8.22	0.55	0.06	1.65
G2 (Repeat)	(m)	1.83	0.30	1.37	2.79	32.32	8.09	0.49	0.06	1.51
	(r)	1.88	0.29	1.40	2.85	32.32	8.15	0.45	0.06	1.51
BEN	(m)	8.89	1.52	9.97	0.91	17.87	5.04	7.78	0.46	1.12
	(r)	9.03	1.57	9.97	0.90	17.93	5.35	7.97	0.46	1.19
BHVO1	(m)	8.73	1.62	8.31	0.35	23.67	7.24	4.34	0.12	0.85
	(r)	8.56	1.61	8.10	0.35	23.30	7.33	4.41	0.12	0.85
MRG1	(m)	12.38	2.18	10.57	0.13	18.37	4.44	7.94	0.03	0.27
	(r)	12.48	2.21	10.56	0.12	18.36	4.50	8.13	0.02	0.26

Results expressed as weigh percent (Wt.%)

all other elements are well above the limit of detection. Accuracy of the measurements was assessed as for major elements. The results are listed in Table B-3 and are acceptable, given that the accuracy of the recommended reference standard values is often not that well constrained.

It should be noted that the extremely high Zn, Cu, Pb and Ba concentrations in the tailings lie outside the concentration range of the available reference standards used to calibrate the XRF. Extrapolation of the calibration curve to the range of the concentrations of these elements measured in the tailings probably introduced some inaccuracy; therefore the levels of these metals in the tailings samples reported in Appendix D should be considered to be good estimates, but not accurate in an absolute sense. This poses no difficulty given that the solid-phase minor element measurements have been used in this study only to assess the relative lateral and vertical distributions of the tailings.

CNS and $CaCO_3$ Analysis

Total carbon, nitrogen and sulphur were determined using elemental analysis. Total C and N were measured using a Carlo-Erba 1106 Elemental Analyzer which combusts the sample in a stream of O_2, separates the combustion gases (CO_2 and N_2 reduced from NO_x) chromatographically, and measures the gas concentrations (thus C and N contents) by thermal conductivity. Sulphur was determined using a Carlo-Erba NA-1500 CNS Analyzer, which employs the same methodology. The use of the two different instruments was required because the high sulphur content of the tailings swamped the C and N channels on the CNS Analyzer with SO_2. The analyzers are calibrated using acetanilide and the NRC marine sediment standards MESS-1 and BCSS-1. Accuracy is excellent; agreement with the recommended values for total C and N is always within analytical precision. The precision of the measurements (1σ, R.S.D.) was about 1.5%, 3% and 3% for C, N and S respectively.

Carbonate carbon was determined on all samples by coulometry using a Coulometrics Analyzer, which electrochemically measures the CO_2 evolved following addition of HCl to a sample. Concentrations were very low in the natural sediments (typically <0.1 wt. %), but ranged up to 0.8 wt.% in the tailings. Precision of the measurements ($1\ \sigma$, R.S.D.) was better than 3% for the higher carbonate carbon concentrations.

Organic carbon was determined by subtracting carbonate carbon from the total C measurements. Precision of the resulting organic C value was about ± 5 % ($1\ \sigma$, R.S.D.).

X-ray Diffraction Analysis

Samples were ground in a tungsten carbide disc mill to pass 200 mesh, and pressed in random orientation into a rigid disc held in an aluminum planchet. The samples were

Table B-3

XRF Minor Element Quality Control Data, Comparing Concentrations Determined for Geochemical Reference Standards in this Study (m), with Concentrations Recommended (r) by Abbey (1983)

		Zr	Sr	Rb	Pb	Zn	Cu	Ni	Co	Mn	V	Cr	Ba
AGV1	(m)	231	610	64	32	72	68	4	17	778	88	29	1123
	(r)	230	660	67	33	86	59	15	16	728	125	10	1200
BHVO1	(m)	171	369	14	3	88	142	97	40	1224	190	279	104
	(r)	180	420	10	n.a.	105	140	120	45	1316	300	320	135
W2	(m)	92	180	21	9	63	91	44	38	1218	202	93	162
	(r)	100	190	21	n.a.	80	105	70	43	1300	260	92	175
NIMS	(m)	35	60	483	3	12	16	25	4	69	23	12	2269
	(r)	33	62	530	5	10	19	7	4	80	10	12	2400
MRG1	(m)	105	254	9	6	164	133	154	86	1128	360	522	10
MRG1(r)	(m)	92	178	17	n.a.	139	140	120	69	1031	326	408	10
	(r)	105	260	8	10	190	135	195	86	1320	520	50	50
G2	(m)	291	437	152	29	76	11	n.d.	5	260	32	16	1863
	(r)	300	480	170	30	84	10	3	5	265	36	8	1900
GSP1	(m)	459	220	231	53	94	35	12	7	300	38	20	1234
	(r)	500	240	250	54	105	33	9	7	326	54	12	1300
SY2	(m)	260	237	171	72	225	6	48	12	2406	35	11	462
	(r)	280	275	220	80	250	5	10	11	2480	52	12	460

Results expressed as $\mu g\ g^{-1}$ (ppm).

scanned using a Philips PW 1775 X-ray diffractometer powered by a Philips PW 1729 constant potential generator and equipped with a Philips PW 1050/70 vertical goniometer. A curved graphite crystal monochromator, an automated divergence slit , a 1° scatter slit, a gas proportional counter and CuKα radiation were used in the analysis. The diffractometer was controlled by a Philips PW 1710/00 microprocessor unit, and the data were reduced using a Zenith Z-150 PC. Analytical conditions employed included scanning from 4° to 60° 2θ in 0.03° 2θ increments, using a counting time of 3 seconds per increment. Diffractograms were recorded using a rate full scale of 500 counts per second, a time constant of 2 sec. and a chart speed of 10 mm/°2θ.

Water Quality and Climate Data

Appendix C

Present Water Quality of Buttle Lake

Rescan

Table C-1

Buttle Lake Water Quality-Station BUT 2

Site Number	BUT 2-A	BUT 2-B	BUT 2-C
Date Sampled	Apr 25/90	Apr 25/90	Apr 25/90
Time	17:15	17:00	16:45
Depth (m)	1	44	88
Physical Tests			
pH (lab)	7.35	7.14	7.08
Conductivity	70.5	88.6	91.5
Turbidity	0.5	0.2	2.1
Hardness (calc)	31.8	38.7	39.6
Suspended Solids	2.0	2.7	4.0
Fixed Solids	2.0	<1.0	3.3
Volatile Solids	<1.0	2.7	<1.0
Dissolved Solids	50.0	70.0	70.0
Anions & Nutrients			
Alkalinity	23.9	24.4	24.0
Sulphate	8.7	15.7	16.7
Chloride	<0.5	<0.5	<0.5
Silicate	3.9	3.9	4.7
T-Phosphorus	0.002	0.002	0.003
NO_3/NO_2	0.064	0.11	0.13
TOC	0.83	0.82	0.80
Dissolved Metals			
Aluminium	0.025	0.027	0.040
Arsenic	0.0003	0.0001	<0.0001
Cadmium	<0.0002	0.0002	0.0003
Copper	0.002	0.003	0.005
Iron	<0.03	<0.03	<0.03
Lead	<0.001	<0.001	0.002
Manganese	<0.005	0.011	0.014
Mercury	<0.00005	<0.00005	<0.00005
Nickel	<0.001	<0.001	<0.001
Zinc	0.022	0.049	0.052
Calcium	11.5	14.2	14.5
Magnesium	0.74	0.78	0.82

Results expressed as milligrams per litre except for pH, Conductivity (µmhos/cm) and Turbidity (NTU)
< = Less than
NO_3/NO_2 = Nitrate/Nitrite nitrogen
TOC = Total Organic Carbon

Table C-2

Buttle Lake Water Quality-Station BUT 4

Site Number	BUT 4-A	BUT 4-B	BUT 4-C
Date Sampled	Apr 25/90	Apr 25/90	Apr 25/90
Time	16:35	16:25	16:10
Depth (m)	1	18	38
Physical Tests			
pH (lab)	7.12	7.07	7.08
Conductivity	71.1	73.9	76.1
Turbidity	0.4	0.4	0.4
Hardness (calc)	31.7	32.3	33.3
Suspended Solids	<1.0	4.0	4.0
Fixed Solids	<1.0	<1.0	<1.0
Volatile Solids	<1.0	4.0	4.0
Dissolved Solids	50.0	60.	60.
Anions & Nutrients			
Alkalinity	22.8	21.9	21.6
Sulphate	9.2	11.5	11.7
Chloride	<0.5	<0.5	<0.5
Silicate	4.0	3.9	3.7
T-Phosphorus	0.002	0.002	0.001
NO_3/NO_2	0.064	0.087	0.088
TOC	0.83	0.95	1.05
Dissolved Metals			
Aluminium	0.024	0.032	0.027
Arsenic	0.0004	0.0003	0.0003
Cadmium	<0.0002	<0.0002	<0.0002
Copper	<0.001	0.002	0.002
Iron	<0.03	<0.03	<0.03
Lead	<0.001	<0.001	<0.001
Manganese	<0.005	0.007	0.009
Mercury	<0.00005	<0.00005	<0.00005
Nickel	<0.001	<0.001	<0.001
Zinc	0.026	0.031	0.036
Calcium	11.4	11.8	12.2
Magnesium	0.70	0.68	0.69

Results expressed as milligrams per litre except for pH,
Conductivity (μmhos/cm) and Turbidity (NTU)
< = Less than
NO_3/NO_2 = Nitrate/Nitrite nitrogen
TOC = Total Organic Carbon

Table C-3

Buttle Lake Water Quality-Station BUT 5

Site Number	BUT 5-A	BUT 5-B	BUT 5-C
Date Sampled	Apr 25/90	Apr 25/90	Apr 25/90
Time	15:08	14:55	14:40
Depth (m)	1	20	40
Physical Tests			
pH (lab)	7.12	7.02	7.08
Conductivity	72.6	78.6	95.6
Turbidity	0.5	0.4	0.9
Hardness (calc)	32.4	34.8	35.7
Suspended Solids	2.7	2.0	5.3
Fixed Solids	2.6	<1.0	2.0
Volatile Solids	<1.0	2.0	3.3
Dissolved Solids	50.	60.	80.
Anions & Nutrients			
Alkalinity	22.3	22.5	21.9
Sulphate	10.0	12.4	12.5
Chloride	<0.5	<0.5	2.7
Silicate	4.1	4.2	4.0
T-Phosphorus	0.002	0.003	0.002
NO_3/NO_2	0.072	0.093	0.083
TOC	0.95	0.94	0.93
Dissolved Metals			
Aluminium	0.024	0.029	0.026
Arsenic	0.0005	0.0004	0.0004
Cadmium	<0.0002	0.0004	<0.0002
Copper	0.002	0.004	0.001
Iron	<0.03	<0.03	<0.03
Lead	<0.001	<0.001	<0.001
Manganese	<0.005	0.008	0.009
Mercury	<0.00005	<0.00005	<0.00005
Nickel	<0.001	<0.001	<0.001
Zinc	0.025	0.040	0.035
Calcium	11.8	12.7	12.5
Magnesium	0.72	0.74	1.10

Results expressed as milligrams per litre except for pH,
Conductivity (µmhos/cm) and Turbidity (NTU)
< = Less than
NO_3/NO_2 = Nitrate/Nitrite nitrogen
TOC = Total Organic Carbon

Table C-4

Buttle Lake Water Quality-Station BUT 6

Site Number	BUT 6-A	BUT 6-B	BUT 6-C
Date Sampled	Apr 25/90	Apr 25/90	Apr 25/90
Time	15:25	15:35	15:50
Depth (m)	1	22	44
Physical Tests			
pH (lab)	7.11	7.14	7.09
Conductivity	74.2	76.5	88.0
Turbidity	0.4	0.3	0.3
Hardness (calc)	32.5	33.0	34.6
Suspended Solids	2.7	<1.0	<1.0
Fixed Solids	<1.0	<1.0	<1.0
Volatile Solids	2.7	<1.0	<1.0
Dissolved Solids	60.	60.	70.
Anions & Nutrients			
Alkalinity	22.0	23.8	23.5
Sulphate	11.6	11.0	15.2
Chloride	<0.5	<0.5	<0.5
Silicate	4.0	4.0	3.6
T-Phosphorus	0.004	0.002	0.004
NO_3/NO_2	0.072	0.089	0.11
TOC	0.97	0.95	0.94
Dissolved Metals			
Aluminium	0.026	0.022	0.027
Arsenic	0.0004	0.0002	0.0002
Cadmium	<0.0002	<0.0002	0.0003
Copper	0.002	<0.001	0.003
Iron	<0.03	<0.03	<0.03
Lead	<0.001	<0.001	<0.001
Manganese	0.008	<0.005	0.009
Mercury	<0.00005	<0.00005	<0.00005
Nickel	<0.001	<0.001	0.001
Zinc	0.033	0.029	0.044
Calcium	11.9	12.0	13.6
Magnesium	0.70	0.74	0.77

Results expressed as milligrams per litre except for pH, Conductivity (µmhos/cm) and Turbidity (NTU)
< = Less than
NO_3/NO_2 = Nitrate/Nitrite nitrogen
TOC = Total Organic Carbon

Appendix C

Historical Water Quality of Buttle Lake

WMB - SEAM DATA

(Negative 9(s) values indicate missing data; other negative values indicate less than detection limits)

Rescan

```
Page No.     1
06/05/90
                          BUTTLE LAKE WATER QUALITY DATA
                          FOR SITES 0130080 AND 0130082

SITE    DATE   TIME DEPTH    PH SPF COND  CA T    CD D    CD T
        y m d  h m      m          uS/cm  mg/l    mg/l    mg/l
------- ------ ---- ----- ----- -------- ----- ------- -------


**  0130080

*  810217
0130080 810217 1005  0.00  7.50       59 -9.99 -0.0005 -0.0005
0130080 810217 1010  5.00  7.50       59 -9.99 -0.0005 -0.0005

*  810312
0130080 810312 1500  0.00  7.50       59 -9.99 -9.9999 -0.0005

*  810414
0130080 810414 1105  0.00  7.60       60 -9.99 -9.9999 -0.0005

*  810624
0130080 810624 1350  0.00  7.40       60 -9.99 -0.0005 -0.0005

*  810819
0130080 810819 1200  0.00  7.80       53 -9.99 -0.0005 -0.0005

*  811117
0130080 811117 1445  0.00  7.50       56 -9.99 -0.0005 -0.0005

*  820223
0130080 820223 1315  0.00  7.30       59 -9.99 -0.0005  0.0005

*  820615
0130080 820615 1500  0.00  7.60       61 -9.99 -0.0005 -0.0005

*  820818
0130080 820818 1450  0.00  7.40       51  8.13 -0.0005 -0.0005

*  821208
0130080 821208 1600  0.00  7.90       56  9.08 -0.0005 -0.0005

*  830324
0130080 830324 1245  0.00 -9.99       58 -9.99 -9.9999 -9.9999

*  830426
0130080 830426 1530  0.00 -9.99       60  9.43 -0.0005  0.0007

*  830517
0130080 830517 1000  0.00  7.50       60  9.47 -0.0005 -0.0005

*  830616
0130080 830616 1200  0.00  5.50       59  6.61  0.0007  0.0007
```

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                          BUTTLE LAKE WATER QUALITY DATA
                          FOR SITES 0130080 AND 0130082

SITE     DATE   TIME DEPTH     PH SPF COND  CA T    CD D    CD T
         y m d  h m      m           uS/cm  mg/l    mg/l    mg/l
------- ------ ---- ----- ----- -------- ----- ------- -------


* 830629
0130080 830629 1420  0.00  7.40       56  8.08 -0.0005 -0.0005
0130080 830629 1430  1.00  7.40       56  8.58 -0.0005  0.0000

* 830719
0130080 830719 1400  0.00  7.40       54  8.45 -0.0005 -0.0005

* 830811
0130080 830811 1600  0.00 -9.99       55  8.10 -0.0005 -0.0005

* 830826
0130080 830826 1400  0.00 -9.99       55  7.45 -0.0005 -0.0005

* 831027
0130080 831027 1200  0.00  6.90       53  7.71 -0.0005 -0.0005

* 831116
0130080 831116 1330  0.00  6.80       55  8.63 -0.0005 -0.0005

* 831215
0130080 831215 1400  0.50  6.80       68  8.91 -0.0005 -0.0005

* 840104
0130080 840104 1500  0.50  7.10       58  8.23 -0.0005 -0.0005

* 840119
0130080 840119 1600  0.50  6.90       59  9.35 -0.0005 -0.0005

* 840229
0130080 840229 1600  0.50  6.80       60  8.91 -0.0005 -0.0005

* 840327
0130080 840327 1400  0.00  6.70       59  9.27 -0.0005 -0.0005

* 840524
0130080 840524 1500  0.00  7.40       61 10.10 -0.0005 -0.0005

* 840619
0130080 840619 1345  0.00  7.10       55  8.80 -0.0005 -0.0005

* 840711
0130080 840711 1500  0.00  7.40       57  9.05 -0.0005 -0.0005

* 840725
0130080 840725 1400  0.00  7.30       56  8.71 -0.0005 -0.0005
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                         BUTTLE LAKE WATER QUALITY DATA
                         FOR SITES 0130080 AND 0130082

SITE     DATE   TIME DEPTH      PH SPF COND  CA T    CD D    CD T
         y m d  h m      m            uS/cm  mg/l    mg/l    mg/l
-------  ------ ---- ----- ----- -------- ----- ------- -------



* 841002
0130080 841002 1330  0.00  7.60        55  8.75 -0.0005 -0.0005

* 841010
0130080 841010 1600  0.00  7.30        54  7.69 -0.0005 -0.0005

* 841211
0130080 841211 1430  0.00  7.00        56  8.81 -0.0005 -0.0005

* 850128
0130080 850128 1600  0.00  7.50        59  9.38 -0.0005 -0.0005

* 850410
0130080 850410 1400  0.00  8.00        61  9.73 -0.0005 -0.0005

* 850709
0130080 850709 1700  0.00  7.70        59  8.37 -0.0005 -0.0005

* 850725
0130080 850725 1530  0.00  7.80        55  7.78 -0.0005 -0.0005

* 850909
0130080 850909 1500  0.00  7.50        60  9.17 -0.0005 -0.0005

* 851024
0130080 851024 1500  0.00  7.60        61  9.98  0.0006  0.0006

* 851204
0130080 851204 1500  0.00  7.30        63 10.40 -9.9999 -0.0005

* 860206
0130080 860206 1330  0.00  7.20        62  8.60 -0.0005 -0.0005

* 860225
0130080 860225 1300  0.00  7.40        62  8.76 -9.9999 -0.0005

* 860319
0130080 860319 1600  0.00  7.10        63  9.72 -0.0005 -0.0005

* 860430
0130080 860430 1500  0.00  7.10        63  9.64 -0.0005 -0.0005

* 860603
0130080 860603 1400  0.00  7.40        62 10.30 -0.0005 -0.0005
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                        BUTTLE LAKE WATER QUALITY DATA
                        FOR SITES 0130080 AND 0130082

SITE     DATE   TIME DEPTH      PH SPF COND  CA T     CD D     CD T
         y m d  h m      m           uS/cm  mg/l     mg/l     mg/l
------- ------ ---- ----- ----- -------- ----- ------- -------



* 870127
0130080 870127 1530  0.00  7.00       61  9.13 -9.9999 -0.0005

* 870218
0130080 870218 1430  0.00  7.30       63  9.78 -0.0005 -0.0005

* 870408
0130080 870408 1000  0.00 -9.99      -99 10.90 -9.9999 -0.0005

* 870505
0130080 870505 1500  0.00 -9.99      -99 10.10 -9.9999 -0.0100

* 870603
0130080 870603 1100  0.00 -9.99      -99 11.00 -9.9999 -0.0005

* 870727
0130080 870727 1200  0.00 -9.99      -99  9.78 -9.9999 -0.0005

* 871015
0130080 871015 1530  0.00  6.90       60  9.50 -0.0005 -0.0005

* 871118
0130080 871118 1100  0.00 -9.99      -99  9.39 -9.9999 -0.0005

* 871208
0130080 871208 1500  0.00  7.00       62 10.00 -0.0005 -0.0005

* 880118
0130080 880118 1400  0.00  7.40       63 10.10 -9.9999 -0.0005

* 880119
0130080 880119 0000  0.00  7.40       63 10.10 -9.9999 -0.0005

* 880208
0130080 880208 1130  0.00  7.30       64  9.60 -9.9999 -0.0005

* 880303
0130080 880303 1415  0.00 -9.99      -99  9.28 -9.9999 -0.0005

* 880413
0130080 880413 0000  0.00  7.10       65  9.88 -0.0100 -0.0100

* 880420
0130080 880420 1400  0.00  7.30       69 10.10 -9.9999 -0.0005
```

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                           BUTTLE LAKE WATER QUALITY DATA
                           FOR SITES 0130080 AND 0130082

SITE    DATE   TIME DEPTH     PH SPF COND  CA T    CD D    CD T
        y m d  h m      m           uS/cm  mg/l    mg/l    mg/l
------- ------ ---- ----- ----- -------- ----- ------- -------


* 880518
0130080 880518 1300  0.00  7.60       66 10.10 -9.9999 -0.0005

* 880615
0130080 880615 1230  0.00  7.60       60  9.90 -9.9999  0.0006

* 880719
0130080 880719 1530  0.00  7.60       59  9.12 -9.9999 -0.0005

* 881103
0130080 881103 1200  0.00  7.30       60  9.40 -9.9999 -0.0005

* 881221
0130080 881221 1500  0.00  7.20       62  9.50 -9.9999 -0.0005

* 890112
0130080 890112 1000  0.00  7.06       60 -9.99 -9.9999 -0.0005

* 890206
0130080 890206 1400  0.00  7.20       60  9.39 -9.9999 -0.0005

* 890307
0130080 890307 0000  0.00  7.40       62  9.94 -9.9999 -9.9999

* 890511
0130080 890511 1200  0.50 -9.99      -99 10.30 -9.9999 -9.9999

* 890614
0130080 890614 1100  0.00  7.40      -99 10.20 -9.9999 -9.9999

* 890710
0130080 890710 1300  0.00  7.20       57  8.66 -9.9999 -0.0005

* 890814
0130080 890814 1500  0.00  7.30       54  9.44 -9.9999  0.0020

* 890907
0130080 890907 1430  0.00  7.70       55  8.74 -9.9999  0.0015

* 891024
0130080 891024 1340  0.00  7.60      -99  9.39 -9.9999 -9.9999

* 891207
0130080 891207 1530  0.00  7.70       60 -9.99 -9.9999 -0.0005
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                         BUTTLE LAKE WATER QUALITY DATA
                         FOR SITES 0130080 AND 0130082

SITE    DATE   TIME DEPTH      PH SPF COND  CA T    CD D    CD T
        y m d  h m      m            uS/cm  mg/l    mg/l    mg/l
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* 891212
0130080 891212 1220  0.00  7.50      -99 10.20 -0.0005 -0.0005

* 900227
0130080 900227 1220  0.00  7.60      -99 -9.99 -9.9999 -9.9999

** 0130082

* 810416
0130082 810416 0000  3.00 -9.99       64 -9.99  0.0080 -9.9999
0130082 810416 0000 15.00 -9.99      -99 -9.99  0.0025 -9.9999
0130082 810416 0000 30.00 -9.99      -99 -9.99  0.0010 -9.9999
0130082 810416 0000 45.00 -9.99       75 -9.99  0.0023 -9.9999

* 810513
0130082 810513 0900  3.00  7.30       60 -9.99  0.0007 -9.9999
0130082 810513 0000 15.00 -9.99      -99 -9.99  0.0007 -9.9999
0130082 810513 0000 30.00 -9.99      -99 -9.99  0.0010 -9.9999
0130082 810513 0900 50.00  7.00       63 -9.99  0.0008 -9.9999

* 810608
0130082 810608 0000  3.00 -9.99      -99 -9.99  0.0012 -9.9999
0130082 810608 0000 15.00 -9.99      -99 -9.99  0.0020 -9.9999
0130082 810608 0000 30.00 -9.99      -99 -9.99  0.0014 -9.9999
0130082 810608 0000 50.00 -9.99      -99 -9.99  0.0015 -9.9999

* 810714
0130082 810714 0000  3.00 -9.99       58 -9.99  0.0011 -9.9999
0130082 810714 0000  3.10 -9.99      -99 -9.99 -0.0005 -9.9999
0130082 810714 0000 15.00 -9.99      -99 -9.99 -0.0005 -9.9999
0130082 810714 0000 30.00 -9.99      -99 -9.99  0.0016 -9.9999
0130082 810714 0000 50.00 -9.99       79 -9.99  0.0012 -9.9999

* 810812
0130082 810812 0000  3.00  7.70       59 -9.99 -0.0005 -9.9999
0130082 810812 0000  3.10 -9.99      -99 -9.99 -0.0005 -9.9999
0130082 810812 0000 15.00 -9.99      -99 -9.99 -0.0005 -9.9999
0130082 810812 0000 30.00 -9.99      -99 -9.99  0.0007 -9.9999
0130082 810812 0000 50.00  7.60       79 -9.99  0.0010 -9.9999

* 810908
0130082 810908 0000  3.00  7.60       60  9.30 -0.0005 -9.9999
0130082 810908 0000  3.10 -9.99      -99 -9.99 -0.0005 -9.9999
0130082 810908 0000 15.00 -9.99      -99 -9.99 -0.0005 -9.9999
```

BUTTLE LAKE WATER QUALITY DATA
FOR SITES 0130080 AND 0130082

SITE	DATE y m d	TIME h m	DEPTH m	PH	SPF COND uS/cm	CA T mg/l	CD D mg/l	CD T mg/l
0130082	810908	0000	30.00	-9.99	-99	-9.99	0.0005	-9.9999
0130082	810908	0000	50.00	7.70	78	12.10	0.0008	-9.9999
* 811020								
0130082	811020	0000	3.00	7.40	59	-9.99	-0.0005	0.0006
0130082	811020	0000	15.00	-9.99	-99	-9.99	-0.0005	-0.0005
0130082	811020	0000	30.00	-9.99	-99	-9.99	0.0006	0.0007
0130082	811020	0000	50.00	7.40	80	-9.99	0.0009	0.0011
* 811118								
0130082	811118	0000	3.00	7.40	55	-9.99	0.0005	-9.9999
0130082	811118	0000	3.10	-9.99	-99	-9.99	0.0005	-9.9999
0130082	811118	0000	15.00	-9.99	-99	-9.99	0.0007	-9.9999
0130082	811118	0000	30.00	-9.99	-99	-9.99	0.0007	-9.9999
0130082	811118	0000	50.00	7.60	73	-9.99	0.0008	-9.9999
* 820119								
0130082	820119	1200	20.00	-9.99	68	-9.99	0.0007	0.0008
* 820215								
0130082	820215	0000	3.00	7.30	66	-9.99	0.0006	0.0006
0130082	820215	0000	3.10	-9.99	-99	-9.99	0.0008	-9.9999
0130082	820215	0000	15.00	-9.99	-99	-9.99	-9.9999	0.0007
0130082	820215	0000	30.00	-9.99	-99	-9.99	0.0010	0.0010
0130082	820215	0000	50.00	7.60	87	-9.99	0.0010	0.0017
* 820614								
0130082	820614	0000	0.50	7.00	62	-9.99	-9.9999	-0.0005
* 830324								
0130082	830324	1120	0.00	-9.99	59	-9.99	-9.9999	-9.9999
* 830426								
0130082	830426	0910	0.00	-9.99	-99	9.91	-9.9999	-0.0005
* 830601								
0130082	830601	0000	0.00	7.70	54	7.77	-9.9999	-0.0005
* 830720								
0130082	830720	0000	0.00	7.70	52	7.34	-9.9999	-0.0005
* 830822								
0130082	830822	0000	0.00	7.70	53	8.10	-9.9999	-0.0050
0130082	830822	0000	20.00	-9.99	-99	8.87	-9.9999	-0.0005
0130082	830822	0000	40.00	-9.99	-99	12.20	-9.9999	0.0009

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                     BUTTLE LAKE WATER QUALITY DATA
                     FOR SITES 0130080 AND 0130082

SITE     DATE   TIME DEPTH      PH SPF COND  CA T    CD D    CD T
         y m d  h m      m             uS/cm  mg/l    mg/l    mg/l
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0130082 830822 0000 100.0 -9.99      -99 12.20 -9.9999  0.0027

*  831025
0130082 831025 1130  0.00  7.50       60  8.20 -9.9999 -0.0005

*  831214
0130082 831214 1500  0.00  7.30       66  9.89 -9.9999 -0.0005
0130082 831214 1500 20.00 -9.99      -99  9.59 -9.9999 -0.0100
0130082 831214 1500 40.00 -9.99      -99  9.84 -9.9999 -0.0100
0130082 831214 1500 132.0 -9.99      -99  9.79 -9.9999 -0.0100

*  840214
0130082 840214 0930  0.00  7.40       67  8.84 -9.9999 -0.0100
0130082 840214 1330 20.00 -9.99      -99  8.12 -9.9999 -0.0100

*  840327
0130082 840327 1200  0.00  7.20       63  8.93 -9.9999 -0.0005
0130082 840327 1204 20.00 -9.99      -99  9.45 -9.9999  0.0007
0130082 840327 1208 40.00 -9.99      -99 11.60 -9.9999  0.0022

*  840501
0130082 840501 1300  0.00  7.50       69  9.81 -9.9999  0.0005
0130082 840501 1300 20.00  7.50       71 10.00 -9.9999  0.0005
0130082 840501 1300 40.00 -9.99      -99 10.60 -9.9999  0.0006
0130082 840501 1305 65.00 -9.99      -99 11.10 -9.9999  0.0007

*  840619
0130082 840619 1250  0.00  7.30       60  8.64 -9.9999 -0.0005
0130082 840619 1245 20.00 -9.99      -99  8.19 -9.9999 -0.0005
0130082 840619 1240 40.00 -9.99      -99 11.30 -9.9999  0.0007
0130082 840619 1230 69.00 -9.99      -99 12.30 -9.9999  0.0024

*  840725
0130082 840725 1440  0.00  7.70       56  8.31 -9.9999 -0.0005
0130082 840725 1430 20.00 -9.99      -99  8.74 -9.9999 -0.0005

*  840822
0130082 840822 1440  0.00  7.10       54  8.77 -9.9999 -0.0005
0130082 840822 1405 20.00 -9.99      -99  9.44 -9.9999 -0.0005
0130082 840822 1410 40.00 -9.99      -99 10.80 -9.9999 -0.0005
0130082 840822 1415 65.00 -9.99      -99 12.40 -9.9999  0.0007

*  841002
0130082 841002 1340  0.00  7.50       55  8.70 -9.9999 -0.0005
0130082 841002 1335 20.00 -9.99      -99  9.88 -9.9999 -0.0005
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BUTTLE LAKE WATER QUALITY DATA
FOR SITES 0130080 AND 0130082

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SITE    DATE   TIME DEPTH     PH SPF COND  CA T    CD D    CD T
        y m d  h m      m           uS/cm  mg/l    mg/l    mg/l
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0130082 841002 1330 40.00 -9.99      -99 11.50 -9.9999  0.0005
0130082 841002 1325 60.00 -9.99      -99 12.50 -9.9999 -0.0005

*  841211
0130082 841211 1410  0.00  7.30       62  8.66 -9.9999 -0.0005
0130082 841211 1400 20.00 -9.99      -99  9.43 -9.9999 -0.0005
0130082 841211 1340 40.00 -9.99      -99  9.35 -9.9999 -0.0005
0130082 841211 1330 60.00 -9.99      -99  9.77 -9.9999 -0.0005

*  850219
0130082 850219 1250  0.00  7.30       67  7.75 -9.9999 -0.0005
0130082 850219 1245 20.00  7.30       69  7.71 -9.9999 -0.0005
0130082 850219 1240 40.00 -9.99      -99 10.40 -9.9999 -0.0005
0130082 850219 1235 65.00 -9.99      -99 11.10 -9.9999 -0.0005

*  850430
0130082 850430 1415  0.00  7.30       69 11.60 -9.9999 -0.0005
0130082 850430 1420 20.00 -9.99      -99 12.20 -9.9999 -0.0005
0130082 850430 1425 40.00 -9.99      -99 11.90 -9.9999 -0.0005
0130082 850430 1430 60.00 -9.99      -99 12.10 -9.9999 -0.0005

*  850604
0130082 850604 1415  0.00  7.20       57  5.85 -9.9999 -0.0005
0130082 850604 1410 20.00 -9.99      -99  5.51 -9.9999 -0.0005
0130082 850604 1405 40.00 -9.99      -99  7.15 -9.9999 -0.0005
0130082 850604 1402 60.00 -9.99      -99  7.49 -9.9999 -0.0005

*  850709
0130082 850709 1400  0.00  7.80       60  8.63 -9.9999 -0.0005
0130082 850709 1405 20.00 -9.99      -99  9.08 -9.9999 -0.0005
0130082 850709 1410 40.00 -9.99      -99 11.30 -9.9999  0.0007
0130082 850709 1415 60.00 -9.99      -99 10.40 -9.9999 -0.0005
0130082 850709 1420 100.0 -9.99      -99 10.80 -9.9999 -0.0005

*  850813
0130082 850813 1130  0.00  7.30       60  9.91 -9.9999 -0.0005
0130082 850813 1105 20.00 -9.99      -99 10.30 -9.9999 -0.0005
0130082 850813 1110 40.00 -9.99      -99 11.40 -9.9999 -0.0005
0130082 850813 1115 60.00 -9.99      -99 11.90 -9.9999 -0.0005

*  850917
0130082 850917 1400  0.00  7.60      -99 10.40 -9.9999 -0.0005
0130082 850917 1400 20.00  7.12      -99 10.20 -9.9999 -0.0005
0130082 850917 1405 40.00 -9.99      -99 11.20 -9.9999 -0.0005
0130082 850917 1410 60.00 -9.99      -99 11.70 -9.9999 -0.0005
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                         BUTTLE LAKE WATER QUALITY DATA
                         FOR SITES 0130080 AND 0130082

SITE     DATE   TIME DEPTH     PH SPF COND  CA T    CD D    CD T
         y m d  h m      m             uS/cm  mg/l    mg/l    mg/l
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* 851022
0130082 851022 1240  0.00  7.10       63 10.30 -9.9999 -0.0005
0130082 851022 1242 20.00 -9.99      -99  9.17 -9.9999  0.0006
0130082 851022 1245 40.00 -9.99      -99 10.80 -9.9999 -0.0005
0130082 851022 1248 60.00 -9.99      -99 11.40 -9.9999 -0.0005

* 851212
0130082 851212 1300  0.00 -9.99       68 11.80 -9.9999 -0.0005
0130082 851212 1255 20.00 -9.99      -99 11.20 -9.9999 -0.0005
0130082 851212 1252 40.00 -9.99      -99 11.30 -9.9999 -0.0005
0130082 851212 1250 60.00 -9.99      -99 12.50 -9.9999 -0.0005

* 860211
0130082 860211 1044  0.00  6.90       61  9.59 -0.0005 -0.0005
0130082 860211 1055 10.00  6.80       61  9.31 -0.0005 -0.0005
0130082 860211 1045 20.00  6.90       77 11.40 -0.0005 -0.0005
0130082 860211 1050 30.00  6.90       78 11.70 -0.0005  0.0006
0130082 860211 1035 40.00  6.90       80 12.30 -0.0005  0.0006
0130082 860211 1040 60.00  6.80       83 14.10 -0.0005 -0.0005

* 860311
0130082 860311 1100  0.00  7.10       66 11.00 -0.0005 -0.0005
0130082 860311 1115 10.00  7.10       66 10.80 -0.0005 -0.0005
0130082 860311 1110 20.00  7.10       68 11.50 -0.0005 -0.0005
0130082 860311 1107 30.00  7.10       73 12.20 -0.0005 -0.0005
0130082 860311 1105 40.00  7.20       76 13.10 -0.0005 -0.0005
0130082 860311 1102 60.00  7.10       80 13.40 -0.0005 -0.0005

* 860415
0130082 860415 1145  0.00  7.20       68 10.60 -0.0005 -0.0005
0130082 860415 1140 10.00  7.20       71 10.60 -0.0005 -0.0005
0130082 860415 1135 20.00  7.20       73 11.30 -0.0005 -0.0005
0130082 860415 1130 30.00  7.10       77 11.60 -0.0005 -0.0005
0130082 860415 1125 40.00  7.20       79 11.90 -0.0005 -0.0005
0130082 860415 1120 60.00 -9.99      -99 12.10 -0.0005 -0.0005

* 860512
0130082 860512 1400  0.00 -9.99       69 11.70 -0.0005 -0.0005
0130082 860512 1400 10.00  7.10      -99 12.70 -0.0005 -0.0005
0130082 860512 1400 20.00  7.10      -99 11.80 -0.0005 -0.0005
0130082 860512 1400 30.00  7.00      -99 11.90 -0.0005 -0.0005
0130082 860512 1400 40.00  6.90      -99 11.80 -0.0005 -0.0005
0130082 860512 1400 60.00  7.00       71 11.50 -0.0005 -0.0005
```

BUTTLE LAKE WATER QUALITY DATA
FOR SITES 0130080 AND 0130082

SITE	DATE y m d	TIME h m	DEPTH m	PH	SPF COND uS/cm	CA T mg/l	CD D mg/l	CD T mg/l
* 860610								
0130082	860610	1200	0.00	7.20	60	9.57	-0.0005	-0.0005
0130082	860610	1200	10.00	7.10	59	9.38	-0.0005	-0.0005
0130082	860610	1200	20.00	7.10	60	9.21	-0.0005	-0.0005
0130082	860610	1200	30.00	7.10	62	9.94	-0.0005	-0.0005
0130082	860610	1200	40.00	7.10	70	11.00	-0.0005	-0.0005
0130082	860610	1200	60.00	7.10	74	11.60	-0.0005	-0.0005
* 860708								
0130082	860708	1415	0.00	7.30	56	8.95	-0.0005	-0.0005
0130082	860708	1418	10.00	7.20	56	9.22	-0.0005	-0.0005
0130082	860708	1413	20.00	7.20	57	9.39	-0.0005	-0.0005
0130082	860708	1410	30.00	7.10	62	10.40	-0.0005	-0.0005
0130082	860708	1408	40.00	7.10	64	11.00	-0.0005	-0.0005
0130082	860708	1406	60.00	7.20	70	12.40	-0.0005	-0.0005
* 860812								
0130082	860812	1128	0.00	7.60	57	9.32	-0.0005	-0.0005
0130082	860812	1130	10.00	7.50	65	10.60	-0.0005	-0.0005
0130082	860812	1135	20.00	7.40	61	9.66	-0.0005	-0.0005
0130082	860812	1115	30.00	7.60	63	10.00	-0.0005	-0.0005
0130082	860812	1120	40.00	7.50	68	11.00	-0.0005	-0.0005
0130082	860812	1125	60.00	7.40	71	11.70	-0.0005	-0.0005
* 870204								
0130082	870204	1230	0.00	7.10	65	9.29	-0.0005	-0.0005
0130082	870204	1230	10.00	7.10	65	9.52	-0.0005	-0.0005
0130082	870204	1230	20.00	7.20	69	10.00	-0.0005	-0.0005
0130082	870204	1230	30.00	7.20	73	11.10	-0.0005	-0.0005
0130082	870204	1230	40.00	7.20	74	10.70	-0.0005	-0.0005
0130082	870204	1230	60.00	7.20	77	10.80	-0.0005	-0.0005
* 870414								
0130082	870414	1115	0.00	7.40	70	11.80	-0.0005	-0.0005
0130082	870414	1115	10.00	7.40	71	11.70	-0.0005	-0.0005
0130082	870414	1115	20.00	7.40	70	11.80	-0.0005	-0.0005
0130082	870414	1115	30.00	7.30	72	11.90	-0.0005	-0.0005
0130082	870414	1115	40.00	7.30	79	13.20	-0.0005	0.0006
0130082	870414	1115	60.00	7.30	78	12.90	-0.0005	-0.0005
* 870708								
0130082	870708	1115	0.00	7.10	56	8.26	-9.9999	-0.0005
0130082	870708	1115	10.00	7.20	55	8.10	-9.9999	-0.0005
0130082	870708	1115	20.00	7.20	58	8.45	-9.9999	-0.0005
0130082	870708	1115	30.00	7.20	62	9.13	-9.9999	-0.0005

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                       BUTTLE LAKE WATER QUALITY DATA
                       FOR SITES 0130080 AND 0130082

SITE     DATE   TIME DEPTH     PH SPF COND  CA T    CD D    CD T
         y m d  h m      m            uS/cm mg/l    mg/l    mg/l
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0130082 870708 1115 40.00  7.10       71 10.20 -9.9999 -0.0005
0130082 870708 1115 60.00  7.10       77 11.20 -9.9999 -0.0005

*  870909
0130082 870909 1430  0.00  7.60       60  9.80 -0.0005 -0.0005
0130082 870909 1430 10.00  7.50       61 10.10 -0.0005 -0.0005
0130082 870909 1430 20.00  7.20       62 10.00 -0.0005 -0.0005
0130082 870909 1430 30.00  7.40       60  9.95 -0.0005 -0.0005
0130082 870909 1430 40.00  7.10       71 11.50 -0.0005 -0.0005
0130082 870909 1430 60.00  7.00       75 11.80 -0.0005 -0.0005

*  871109
0130082 871109 1300  0.00  7.20       67 10.40 -0.0005 -0.0005

*  880119
0130082 880119 1300  0.00  7.40       72 11.20 -0.0005 -0.0005

*  880308
0130082 880308 1000  0.00  7.30       80 12.30 -0.0005 -0.0005

*  880510
0130082 880510 1200  0.00  7.70       67 10.70 -0.0005 -0.0005
0130082 880510 1205 10.00  7.50       63 10.80 -0.0005 -0.0005
0130082 880510 1210 20.00  7.50       67 11.10 -0.0005 -0.0005
0130082 880510 1215 30.00  7.40       82 14.20 -0.0005 -0.0005
0130082 880510 1220 40.00  7.60       72 12.80 -0.0005 -0.0005
0130082 880510 1225 60.00  7.40       91 15.00 -0.0005 -0.0005

*  880706
0130082 880706 1100  0.00  7.60       62  9.80 -0.0005 -0.0005
0130082 880706 1102 10.00  7.60       61  9.71 -0.0005 -0.0005
0130082 880706 1104 20.00  7.50       63  9.97 -0.0005  0.0005
0130082 880706 1106 30.00  7.40       74 12.10 -0.0005 -0.0005
0130082 880706 1108 40.00  7.40       80 13.10 -0.0005 -0.0005
0130082 880706 1110 60.00  7.10       87 14.10 -0.0005 -0.0005

*  880913
0130082 880913 1245  0.00  7.20       61 10.10 -0.0005 -0.0005
0130082 880913 1245 10.00  7.40       63 10.50 -0.0005 -0.0005
0130082 880913 1245 20.00  7.40       66 10.90 -0.0005 -0.0005
0130082 880913 1245 30.00  7.40       70 11.20 -0.0005 -0.0005
0130082 880913 1245 40.00  7.30       77 12.20 -0.0005 -0.0005
0130082 880913 1245 60.00  7.20       83 13.70 -0.0005 -0.0005
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                    BUTTLE LAKE WATER QUALITY DATA
                    FOR SITES 0130080 AND 0130082

SITE    DATE   TIME DEPTH      PH SPF COND  CA T    CD D    CD T
        y m d  h m      m           uS/cm  mg/l    mg/l    mg/l
------- ------ ---- ----- ----- -------- ----- ------- -------


*  881108
0130082 881108 1115  0.00  7.70       62 10.10 -9.9999 -9.9999
0130082 881108 1117 10.00  7.60       61 10.20 -9.9999 -9.9999
0130082 881108 1118 20.00  7.40       57  9.20 -9.9999 -9.9999
0130082 881108 1120 30.00  7.40       64 10.50 -9.9999 -9.9999
0130082 881108 1122 40.00  7.30       74 12.20 -9.9999 -9.9999
0130082 881108 1125 60.00  7.30       80 13.10 -9.9999 -9.9999

*  890118
0130082 890118 1130  0.00  7.40       81 12.00 -0.0005 -0.0005
0130082 890118 1131 10.00  7.30       81 11.60 -0.0005 -0.0005
0130082 890118 1132 20.00  7.30       81 11.20 -0.0005 -0.0005
0130082 890118 1133 30.00  7.40       81 11.20 -0.0005 -0.0005
0130082 890118 1134 40.00  7.40       81 11.60 -0.0005 -0.0005
0130082 890118 1135 50.00  7.30       83 11.70 -0.0005 -0.0005

*  890307
0130082 890307 1100  0.00  7.40       75 12.40 -9.9999 -9.9999

*  890613
0130082 890613 1300  0.00  7.70       57  9.16 -9.9999 -9.9999
0130082 890613 1205 10.00  7.70       54  8.90 -9.9999 -9.9999
0130082 890613 1210 20.00 -9.99      -99 10.70 -9.9999 -9.9999
0130082 890613 1211 30.00  7.70       70 12.10 -9.9999 -9.9999
0130082 890613 1215 40.00  7.70       78 13.10 -9.9999 -9.9999
0130082 890613 1218 60.00  7.60       82 13.80 -9.9999 -9.9999

*  890822
0130082 890822 1000  0.00  7.80       60  9.78 -9.9999 -9.9999
0130082 890822 1002 10.00  7.60       72 11.70 -9.9999 -9.9999
0130082 890822 1004 20.00  7.50       64 10.50 -9.9999 -9.9999
0130082 890822 1006 30.00  7.50       68 11.20 -9.9999 -9.9999
0130082 890822 1008 40.00  7.40       74 12.20 -9.9999 -9.9999
0130082 890822 1010 60.00  7.40       80 13.10 -9.9999 -9.9999

*  891024
0130082 891024 1050  0.00  7.40       64 10.10 -9.9999 -9.9999
0130082 891024 1052 10.00  7.50       61  9.58 -9.9999 -9.9999
0130082 891024 1054 20.00  7.40       55  8.64 -9.9999 -9.9999
0130082 891024 1056 30.00  7.40       67 10.60 -9.9999 -9.9999
0130082 891024 1058 40.00  7.30       72 11.50 -9.9999 -9.9999
0130082 891024 1100 60.00  7.30       77 12.30 -9.9999 -9.9999

*  891212
0130082 891212 1000  0.00  7.70       62 10.50 -0.0005 -0.0005
```

BUTTLE LAKE WATER QUALITY DATA
FOR SITES 0130080 AND 0130082

SITE	DATE y m d	TIME h m	DEPTH m	PH	SPF COND uS/cm	CA T mg/l	CD D mg/l	CD T mg/l
0130082	891212	1002	10.00	7.50	62	10.40	-0.0005	-0.0005
0130082	891212	1004	20.00	7.40	60	9.79	-0.0005	-0.0005
0130082	891212	1006	30.00	7.50	63	10.90	-0.0005	-0.0005
0130082	891212	1008	40.00	7.40	68	11.40	-0.0005	-0.0005
0130082	891212	1010	60.00	7.30	78	13.60	-0.0005	-0.0005

BUTTLE LAKE WATER QUALITY DATA

```
SITE    DATE   DEPTH   CU D    CU T   FE D  FE T  MG T  MN D  MN T
        y m d      m   mg/l    mg/l   mg/l  mg/l  mg/l  mg/l  mg/l
------- ------ ----- ------  ------ ----- ----- ----- ----- -----


** 0130080

*  810217
0130080 810217  0.00  0.004   0.005 -9.99 -9.99 -9.99 -9.99 -9.99
0130080 810217  5.00  0.003   0.006 -9.99 -9.99 -9.99 -9.99 -9.99

*  810312
0130080 810312  0.00 -9.999   0.010 -9.99 -9.99 -9.99 -9.99 -9.99

*  810414
0130080 810414  0.00 -9.999   0.007 -9.99 -9.99 -9.99 -9.99 -9.99

*  810624
0130080 810624  0.00  0.003   0.007 -9.99 -9.99 -9.99 -9.99 -9.99

*  810819
0130080 810819  0.00  0.001   0.002 -9.99 -9.99 -9.99 -9.99 -9.99

*  811117
0130080 811117  0.00  0.003   0.005 -9.99 -9.99 -9.99 -9.99 -9.99

*  820223
0130080 820223  0.00  0.003   0.006 -9.99 -9.99 -9.99 -9.99 -9.99

*  820615
0130080 820615  0.00  0.004   0.004 -9.99 -9.99 -9.99 -9.99 -9.99

*  820818
0130080 820818  0.00  0.002   0.003 -0.01  0.03  0.75 -0.01  0.01

*  821208
0130080 821208  0.00  0.002   0.004  0.03  0.05  0.72 -0.01  0.01

*  830324
0130080 830324  0.00 -9.999  -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

*  830426
0130080 830426  0.00  0.003   0.004  0.02  0.03  0.80  0.01  0.02

*  830517
0130080 830517  0.00  0.004   0.002  0.02  0.02  0.96  0.01  0.01

*  830616
0130080 830616  0.00  0.020   0.020  0.04  0.11  0.60 -0.01 -0.01
```

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                        BUTTLE LAKE WATER QUALITY DATA

SITE     DATE    DEPTH    CU D    CU T    FE D   FE T   MG T   MN D   MN T
        y m d        m    mg/l    mg/l    mg/l   mg/l   mg/l   mg/l   mg/l
------- ------  -----  ------  ------  -----  -----  -----  -----  -----


*  830629
0130080 830629   0.00   0.001   0.003   0.02   0.04   0.74  -0.01  -0.01
0130080 830629   1.00   0.001   0.003   0.03   0.03   0.55  -0.01  -0.01

*  830719
0130080 830719   0.00   0.002   0.002   0.03   0.23   0.70  -0.01  -0.01

*  830811
0130080 830811   0.00   0.002   0.002  -0.01  -0.01   0.88  -0.01  -0.01

*  830826
0130080 830826   0.00   0.002   0.004   0.02   0.04   0.73  -0.01  -0.01

*  831027
0130080 831027   0.00  -0.001   0.004  -0.01   0.07   0.74  -0.01  -0.01

*  831116
0130080 831116   0.00  -0.001   0.003   0.02   0.03   0.64  -0.01  -0.01

*  831215
0130080 831215   0.50  -0.001   0.003   0.01   0.06   0.80  -0.01   0.01

*  840104
0130080 840104   0.50   0.003   0.004   0.02   0.13   0.87  -0.01   0.02

*  840119
0130080 840119   0.50   0.002   0.003  -0.01  -0.01   0.76  -0.01  -0.01

*  840229
0130080 840229   0.50   0.001   0.003  -0.01   0.02   0.76  -0.01  -0.01

*  840327
0130080 840327   0.00   0.001   0.003  -0.01  -0.01   0.81  -0.01  -0.01

*  840524
0130080 840524   0.00   0.002   0.002   0.02   0.04   0.98  -0.01   0.01

*  840619
0130080 840619   0.00   0.001   0.002  -0.01   0.11   0.98  -0.01   0.01

*  840711
0130080 840711   0.00   0.003   0.004   0.02   0.25   0.86  -0.01  -0.01

*  840725
0130080 840725   0.00  -0.001   0.003   0.02   0.13   0.85  -0.01   0.01
```

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                        BUTTLE LAKE WATER QUALITY DATA

SITE      DATE    DEPTH    CU D     CU T    FE D   FE T   MG T   MN D   MN T
          y m d       m    mg/l     mg/l    mg/l   mg/l   mg/l   mg/l   mg/l
-------  ------  -----  ------   ------  -----  -----  -----  -----  -----


*  841002
0130080 841002   0.00 -0.001    0.002  -0.01   0.04   0.71  -0.01  -0.01

*  841010
0130080 841010   0.00  0.001    0.003  -0.01   0.11   0.70  -0.01  -0.01

*  841211
0130080 841211   0.00  0.002    0.002   0.03   0.07   0.93  -0.01  -0.01

*  850128
0130080 850128   0.00  0.002    0.003  -0.01   0.15   0.95  -0.01  -0.01

*  850410
0130080 850410   0.00  0.002    0.003   0.02   0.09   0.90  -0.01  -0.01

*  850709
0130080 850709   0.00  0.003    0.003  -0.01   0.04   0.74  -0.01  -0.01

*  850725
0130080 850725   0.00 -0.001    0.002  -0.01   0.09   0.84  -0.01  -0.01

*  850909
0130080 850909   0.00 -0.001   -0.001  -0.01  -0.01   0.80  -0.01  -0.01

*  851024
0130080 851024   0.00  0.001    0.002   0.01   0.05   0.89  -0.01  -0.01

*  851204
0130080 851204   0.00 -9.999    0.001  -9.99  -0.01  -9.99  -9.99  -0.01

*  860206
0130080 860206   0.00  0.001    0.002   0.02   0.02   0.83  -0.01  -0.01

*  860225
0130080 860225   0.00 -9.999    0.003  -9.99  -0.01  -9.99  -9.99  -0.01

*  860319
0130080 860319   0.00  0.002    0.003  -0.01   0.02   0.93  -0.01  -0.01

*  860430
0130080 860430   0.00  0.002    0.003  -0.01   0.01   0.89  -0.01  -0.01

*  860603
0130080 860603   0.00  0.002    0.003   0.02   0.02   0.84  -0.01  -0.01
```

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                    BUTTLE LAKE WATER QUALITY DATA

SITE     DATE    DEPTH   CU D    CU T   FE D   FE T   MG T   MN D   MN T
         y m d       m   mg/l    mg/l   mg/l   mg/l   mg/l   mg/l   mg/l
------- ------ ----- ------ ------ ----- ----- ----- ----- -----


* 870127
0130080 870127  0.00 -9.999  0.003 -9.99   0.05   0.77 -9.99 -0.01

* 870218
0130080 870218  0.00  0.001  0.002  0.02   0.03   0.90 -0.01 -0.01

* 870408
0130080 870408  0.00 -9.999  0.004 -9.99  -0.10   0.89 -9.99 -0.01

* 870505
0130080 870505  0.00 -9.999  0.003 -9.99   0.03   0.78 -9.99 -0.01

* 870603
0130080 870603  0.00 -9.999  0.002 -9.99   0.04   0.88 -9.99 -0.01

* 870727
0130080 870727  0.00 -9.999  0.002 -9.99   0.07   0.83 -9.99 -0.01

* 871015
0130080 871015  0.00  0.004  0.004  0.01   0.03   0.80 -0.01 -0.01

* 871118
0130080 871118  0.00 -9.999  0.005 -9.99   0.08   0.80 -9.99 -0.01

* 871208
0130080 871208  0.00 -0.001  0.002 -0.01   0.06   0.82 -0.01 -0.01

* 880118
0130080 880118  0.00 -9.999  0.002 -9.99   0.08   0.86 -9.99 -0.01

* 880119
0130080 880119  0.00 -9.999  0.003 -9.99   0.07   0.88 -9.99 -0.01

* 880208
0130080 880208  0.00 -9.999  0.002 -9.99   0.05   0.86 -9.99 -0.01

* 880303
0130080 880303  0.00 -9.999  0.003 -9.99   0.04   0.85 -9.99 -0.01

* 880413
0130080 880413  0.00  0.002  0.003 -0.01   0.05   0.87 -0.01 -0.01

* 880420
0130080 880420  0.00 -9.999  0.002 -9.99   0.06   0.89 -9.99 -0.01
```

BUTTLE LAKE WATER QUALITY DATA

SITE	DATE y m d	DEPTH m	CU D mg/l	CU T mg/l	FE D mg/l	FE T mg/l	MG T mg/l	MN D mg/l	MN T mg/l
* 880518									
0130080	880518	0.00	-9.999	0.002	-9.99	0.07	0.88	-9.99	-0.01
* 880615									
0130080	880615	0.00	-9.999	0.003	-9.99	0.03	0.87	-9.99	-0.01
* 880719									
0130080	880719	0.00	-9.999	-0.001	-9.99	0.09	0.85	-9.99	-0.01
* 881103									
0130080	881103	0.00	-9.999	0.002	-9.99	0.04	0.73	-9.99	-0.01
* 881221									
0130080	881221	0.00	-9.999	0.001	-9.99	0.03	0.79	-9.99	-0.01
* 890112									
0130080	890112	0.00	-9.999	0.004	-9.99	-9.99	-9.99	-9.99	-9.99
* 890206									
0130080	890206	0.00	-9.999	0.002	-9.99	0.02	0.80	-9.99	-0.01
* 890307									
0130080	890307	0.00	-0.001	0.003	-0.01	0.04	0.85	-0.01	-0.01
* 890511									
0130080	890511	0.50	0.001	0.005	-0.01	0.02	0.87	-0.01	-0.01
* 890614									
0130080	890614	0.00	0.002	0.002	-0.01	0.01	0.80	-0.01	-0.01
* 890710									
0130080	890710	0.00	0.001	0.001	-9.99	-0.01	0.73	-9.99	-0.01
* 890814									
0130080	890814	0.00	-9.999	0.001	-9.99	0.04	0.80	-9.99	-0.01
* 890907									
0130080	890907	0.00	-9.999	0.001	-9.99	0.08	0.78	-9.99	-0.01
* 891024									
0130080	891024	0.00	-0.001	-0.001	-0.01	-0.01	0.72	-0.01	-0.01
* 891207									
0130080	891207	0.00	-9.999	0.002	-9.99	-9.99	-9.99	-9.99	-9.99

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                         BUTTLE LAKE WATER QUALITY DATA

SITE     DATE    DEPTH    CU D    CU T   FE D   FE T   MG T   MN D   MN T
         y m d      m     mg/l    mg/l   mg/l   mg/l   mg/l   mg/l   mg/l
------- ------ ----- ------ ------ ----- ----- ----- ----- -----


*  891212
0130080 891212  0.00  0.002  0.002 -0.01  0.03  0.77 -0.01 -0.01

*  900227
0130080 900227  0.00 -9.999 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

**  0130082

*  810416
0130082 810416  3.00  0.020 -9.999 -9.99 -9.99  0.98 -9.99 -9.99
0130082 810416 15.00  0.020 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810416 30.00  0.030 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810416 45.00  0.040 -9.999 -9.99 -9.99  1.10 -9.99 -9.99

*  810513
0130082 810513  3.00  0.009 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810513 15.00  0.013 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810513 30.00  0.016 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810513 50.00  0.015 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

*  810608
0130082 810608  3.00  0.012 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810608 15.00  0.020 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810608 30.00  0.030 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810608 50.00  0.020 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

*  810714
0130082 810714  3.00  0.005 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810714  3.10  0.005 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810714 15.00  0.005 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810714 30.00  0.010 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810714 50.00  0.010 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

*  810812
0130082 810812  3.00  0.002 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810812  3.10  0.002 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810812 15.00  0.005 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810812 30.00  0.007 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810812 50.00  0.009 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

*  810908
0130082 810908  3.00  0.001 -9.999 -9.99 -9.99  0.86 -9.99 -9.99
0130082 810908  3.10  0.003 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810908 15.00  0.005 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810908 30.00  0.006 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
0130082 810908 50.00  0.007 -9.999 -9.99 -9.99  0.98 -9.99 -9.99
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```
                     BUTTLE LAKE WATER QUALITY DATA

SITE     DATE   DEPTH   CU D    CU T   FE D  FE T  MG T  MN D  MN T
         y m d      m   mg/l    mg/l   mg/l  mg/l  mg/l  mg/l  mg/l
------- ------ ----- ------ ------ ----- ----- ----- ----- -----


* 811020
 0130082 811020  3.00  0.005  0.007 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 811020 15.00  0.010  0.016 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 811020 30.00  0.007  0.010 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 811020 50.00  0.008  0.010 -9.99 -9.99 -9.99 -9.99 -9.99

* 811118
 0130082 811118  3.00  0.007 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 811118  3.10  0.007 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 811118 15.00  0.011 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 811118 30.00  0.012 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 811118 50.00  0.007 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

* 820119
 0130082 820119 20.00 -9.999 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

* 820215
 0130082 820215  3.00  0.008  0.009 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 820215  3.10  0.007 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 820215 15.00 -9.999 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 820215 30.00 -9.999 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99
 0130082 820215 50.00  0.009 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

* 820614
 0130082 820614  0.50 -9.999  0.004 -9.99 -9.99 -9.99 -9.99 -9.99

* 830324
 0130082 830324  0.00 -9.999 -9.999 -9.99 -9.99 -9.99 -9.99 -9.99

* 830426
 0130082 830426  0.00 -9.999  0.005 -9.99 -0.10  0.77 -9.99  0.02

* 830601
 0130082 830601  0.00 -9.999  0.003 -9.99  0.05  0.65 -9.99 -0.01

* 830720
 0130082 830720  0.00 -9.999  0.005 -9.99  0.03  0.69 -9.99 -0.01

* 830822
 0130082 830822  0.00 -9.999  0.004 -9.99  0.03  0.67 -9.99 -0.01
 0130082 830822 20.00 -9.999  0.004 -9.99  0.06  0.73 -9.99  0.01
 0130082 830822 40.00 -9.999  0.100 -9.99  0.92  1.12 -9.99  0.06
 0130082 830822 100.0 -9.999  0.310 -9.99  9.30  4.34 -9.99  0.21
```

```
                         BUTTLE LAKE WATER QUALITY DATA

SITE     DATE   DEPTH    CU D    CU T   FE D  FE T  MG T  MN D  MN T
         y m d      m   mg/l    mg/l   mg/l  mg/l  mg/l  mg/l  mg/l
------- ------ ----- ------ ------ ----- ----- ----- ----- -----


*  831025
0130082 831025  0.00 -9.999  0.003 -9.99  0.07  0.71 -9.99  0.01

*  831214
0130082 831214  0.00 -9.999  0.009 -9.99  0.11  0.77 -9.99  0.03
0130082 831214 20.00 -9.999  0.020 -9.99  0.13  0.78 -9.99  0.04
0130082 831214 40.00 -9.999  0.010 -9.99  0.12  0.81 -9.99  0.04
0130082 831214 132.0 -9.999  0.030 -9.99  0.31  0.90 -9.99  0.04

*  840214
0130082 840214  0.00 -9.999  0.020 -9.99  0.06  0.87 -9.99  0.04
0130082 840214 20.00 -9.999  0.020 -9.99  0.11  0.77 -9.99  0.04

*  840327
0130082 840327  0.00 -9.999  0.009 -9.99  0.03  0.68 -9.99  0.03
0130082 840327 20.00 -9.999  0.011 -9.99  0.04  0.76 -9.99  0.04
0130082 840327 40.00 -9.999  0.140 -9.99  7.20  2.91 -9.99  0.33

*  840501
0130082 840501  0.00 -9.999  0.007 -9.99  0.10  0.81 -9.99  0.03
0130082 840501 20.00 -9.999  0.009 -9.99  0.09  0.79 -9.99  0.03
0130082 840501 40.00 -9.999  0.010 -9.99  0.18  0.93 -9.99  0.04
0130082 840501 65.00 -9.999  0.013 -9.99  0.44  0.99 -9.99  0.05

*  840619
0130082 840619  0.00 -9.999  0.003 -9.99  0.05  0.88 -9.99  0.01
0130082 840619 20.00 -9.999  0.005 -9.99  0.07  0.72 -9.99  0.01
0130082 840619 40.00 -9.999  0.012 -9.99  0.34  1.07 -9.99  0.05
0130082 840619 69.00 -9.999  0.290 -9.99 10.50  4.37 -9.99  0.26

*  840725
0130082 840725  0.00 -9.999  0.002 -9.99  0.03  0.76 -9.99 -0.01
0130082 840725 20.00 -9.999  0.003 -9.99  0.05  0.66 -9.99 -0.01

*  840822
0130082 840822  0.00 -9.999  0.002 -9.99  0.06  0.75 -9.99 -0.01
0130082 840822 20.00 -9.999  0.003 -9.99 -0.01  0.73 -9.99 -0.01
0130082 840822 40.00 -9.999  0.005 -9.99  0.09  0.88 -9.99  0.02
0130082 840822 65.00 -9.999  0.012 -9.99  0.07  0.97 -9.99  0.05

*  841002
0130082 841002  0.00 -9.999  0.002 -9.99  0.06  0.65 -9.99 -0.01
0130082 841002 20.00 -9.999  0.004 -9.99  0.10  0.76 -9.99 -0.01
0130082 841002 40.00 -9.999  0.007 -9.99  0.08  0.80 -9.99  0.04
0130082 841002 60.00 -9.999  0.007 -9.99  0.10  0.85 -9.99  0.05
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BUTTLE LAKE WATER QUALITY DATA

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SITE     DATE    DEPTH   CU D    CU T    FE D  FE T  MG T  MN D  MN T
         y m d       m   mg/l    mg/l    mg/l  mg/l  mg/l  mg/l  mg/l
-------- ------ ----- ------ ------ ----- ----- ----- ----- -----

*  841211
0130082 841211  0.00 -9.999   0.005 -9.99  0.09  0.83 -9.99  0.01
0130082 841211 20.00 -9.999   0.005 -9.99  0.12  0.86 -9.99  0.03
0130082 841211 40.00 -9.999   0.005 -9.99  0.11  0.87 -9.99  0.03
0130082 841211 60.00 -9.999   0.005 -9.99  0.13  0.88 -9.99  0.04

*  850219
0130082 850219  0.00 -9.999   0.005 -9.99  0.08  0.90 -9.99  0.02
0130082 850219 20.00 -9.999   0.010 -9.99  0.06  1.00 -9.99  0.02
0130082 850219 40.00 -9.999   0.007 -9.99  1.01 -0.02 -9.99  0.02
0130082 850219 65.00 -9.999   0.008 -9.99  0.04  1.04 -9.99  0.03

*  850430
0130082 850430  0.00 -9.999   0.007 -9.99  0.07  0.92 -9.99  0.02
0130082 850430 20.00 -9.999   0.007 -9.99  0.06  0.99 -9.99  0.02
0130082 850430 40.00 -9.999   0.008 -9.99  0.09  0.92 -9.99  0.03
0130082 850430 60.00 -9.999   0.007 -9.99  0.07  0.94 -9.99  0.03

*  850604
0130082 850604  0.00 -9.999   0.003 -9.99  0.03  0.76 -9.99  0.01
0130082 850604 20.00 -9.999   0.006 -9.99  0.04  0.68 -9.99  0.01
0130082 850604 40.00 -9.999   0.005 -9.99  0.05  0.87 -9.99  0.02
0130082 850604 60.00 -9.999   0.007 -9.99  0.05  0.86 -9.99  0.02

*  850709
0130082 850709  0.00 -9.999  -0.001 -9.99  0.03  0.77 -9.99 -0.01
0130082 850709 20.00 -9.999   0.003 -9.99  0.06  0.75 -9.99 -0.01
0130082 850709 40.00 -9.999   0.020 -9.99  0.07  0.92 -9.99  0.01
0130082 850709 60.00 -9.999   0.003 -9.99  0.07  0.83 -9.99  0.02
0130082 850709 100.0 -9.999   0.002 -9.99  0.06  0.87 -9.99  0.02

*  850813
0130082 850813  0.00 -9.999  -0.001 -9.99  0.07  0.73 -9.99 -0.01
0130082 850813 20.00 -9.999   0.003 -9.99 -0.01  0.73 -9.99 -0.01
0130082 850813 40.00 -9.999   0.004 -9.99  0.16  0.80 -9.99  0.01
0130082 850813 60.00 -9.999   0.004 -9.99 -0.01  0.85 -9.99  0.01

*  850917
0130082 850917  0.00 -9.999  -0.001 -9.99  0.04  0.77 -9.99 -0.01
0130082 850917 20.00 -9.999   0.002 -9.99  0.03  0.77 -9.99 -0.01
0130082 850917 40.00 -9.999   0.005 -9.99  0.02  0.82 -9.99  0.02
0130082 850917 60.00 -9.999   0.004 -9.99  0.04  0.86 -9.99  0.03

*  851022
0130082 851022  0.00 -9.999   0.002 -9.99  0.02  0.79 -9.99 -0.01
0130082 851022 20.00 -9.999   0.030 -9.99  0.21  0.70 -9.99  0.02
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BUTTLE LAKE WATER QUALITY DATA

SITE	DATE y m d	DEPTH m	CU D mg/l	CU T mg/l	FE D mg/l	FE T mg/l	MG T mg/l	MN D mg/l	MN T mg/l
0130082	851022	40.00	-9.999	0.020	-9.99	0.07	0.85	-9.99	0.01
0130082	851022	60.00	-9.999	0.020	-9.99	0.07	0.87	-9.99	0.03
* 851212									
0130082	851212	0.00	-9.999	0.004	-9.99	0.07	0.82	-9.99	0.01
0130082	851212	20.00	-9.999	0.009	-9.99	0.11	0.83	-9.99	0.01
0130082	851212	40.00	-9.999	0.009	-9.99	0.11	0.81	-9.99	0.02
0130082	851212	60.00	-9.999	0.009	-9.99	0.05	0.82	-9.99	0.03
* 860211									
0130082	860211	0.00	-0.001	0.003	0.04	0.05	0.67	0.01	0.02
0130082	860211	10.00	0.004	0.005	0.03	0.06	0.65	0.01	0.02
0130082	860211	20.00	0.005	0.006	0.04	0.06	0.78	0.02	0.02
0130082	860211	30.00	0.007	0.009	0.05	0.09	0.76	0.03	0.03
0130082	860211	40.00	0.008	0.020	0.06	0.09	0.75	0.03	0.04
0130082	860211	60.00	0.007	0.020	0.05	0.09	0.80	0.04	0.05
* 860311									
0130082	860311	0.00	0.004	-0.010	-0.01	0.08	0.65	0.01	0.04
0130082	860311	10.00	0.004	-0.010	0.02	0.06	0.63	0.02	0.02
0130082	860311	20.00	0.007	0.010	0.02	0.06	0.75	0.02	0.02
0130082	860311	30.00	0.005	-0.010	0.02	0.03	0.71	0.02	0.02
0130082	860311	40.00	0.006	0.020	0.02	0.05	0.73	0.02	0.02
0130082	860311	60.00	0.006	0.010	0.03	0.05	0.75	0.03	0.03
* 860415									
0130082	860415	0.00	0.005	-0.010	0.02	0.09	0.82	0.01	0.02
0130082	860415	10.00	0.005	0.010	0.02	-0.01	0.80	0.02	0.02
0130082	860415	20.00	0.004	0.010	0.02	0.08	0.80	0.03	0.03
0130082	860415	30.00	0.005	0.010	0.18	0.03	0.74	0.03	0.04
0130082	860415	40.00	0.005	0.010	0.02	0.02	0.79	0.04	0.04
0130082	860415	60.00	0.005	0.010	0.02	0.02	0.80	0.04	0.04
* 860512									
0130082	860512	0.00	0.004	-0.010	-0.01	-0.01	0.82	-0.01	0.02
0130082	860512	10.00	0.003	-0.010	0.01	-0.01	0.82	-0.01	0.02
0130082	860512	20.00	0.004	-0.010	0.06	-0.01	0.89	-0.01	0.02
0130082	860512	30.00	0.007	-0.010	0.01	-0.01	0.97	0.02	0.02
0130082	860512	40.00	0.006	-0.010	0.03	0.03	0.81	0.02	0.03
0130082	860512	60.00	0.003	-0.010	-0.01	0.01	0.80	-0.01	0.02
* 860610									
0130082	860610	0.00	0.002	-0.010	-0.01	-0.01	0.74	-0.01	-0.01
0130082	860610	10.00	0.002	-0.010	0.02	0.02	0.67	-0.01	-0.01
0130082	860610	20.00	0.002	-0.010	0.02	0.02	0.55	-0.01	-0.01
0130082	860610	30.00	0.003	-0.010	0.02	0.03	0.59	-0.01	-0.01

BUTTLE LAKE WATER QUALITY DATA

SITE	DATE y m d	DEPTH m	CU D mg/l	CU T mg/l	FE D mg/l	FE T mg/l	MG T mg/l	MN D mg/l	MN T mg/l
0130082	860610	40.00	0.004	-0.010	0.02	0.04	0.73	0.01	0.02
0130082	860610	60.00	0.004	-0.010	0.02	0.04	0.75	0.02	0.02
* 860708									
0130082	860708	0.00	0.001	-0.010	0.01	0.02	0.69	-0.01	-0.01
0130082	860708	10.00	-0.001	-0.010	0.02	0.02	0.61	-0.01	-0.01
0130082	860708	20.00	-0.001	-0.010	0.03	0.03	0.62	-0.01	-0.01
0130082	860708	30.00	0.004	-0.010	0.03	0.03	0.75	-0.01	-0.01
0130082	860708	40.00	0.005	-0.010	-9.99	0.03	0.76	-0.01	0.01
0130082	860708	60.00	0.003	-0.010	0.03	0.04	0.75	0.02	0.02
* 860812									
0130082	860812	0.00	0.001	-0.010	-0.01	-0.01	0.75	-0.01	-0.01
0130082	860812	10.00	0.001	-0.010	0.01	-0.01	0.67	-0.01	-0.01
0130082	860812	20.00	0.002	-0.010	-0.01	-0.01	0.70	-0.01	-0.01
0130082	860812	30.00	0.002	-0.010	0.01	-0.01	0.73	-0.01	-0.01
0130082	860812	40.00	0.002	-0.010	0.08	-0.01	0.71	0.01	0.01
0130082	860812	60.00	0.003	-0.010	0.02	-0.01	0.74	0.02	0.02
* 870204									
0130082	870204	0.00	0.005	-0.010	0.03	0.03	0.69	0.02	0.03
0130082	870204	10.00	0.005	-0.010	0.03	0.03	0.69	0.02	0.03
0130082	870204	20.00	0.006	-0.010	0.02	0.03	0.70	0.03	0.04
0130082	870204	30.00	0.006	0.010	0.02	0.05	0.76	0.04	0.04
0130082	870204	40.00	0.006	0.010	0.03	0.05	0.74	0.04	0.04
0130082	870204	60.00	0.007	0.010	0.04	0.06	0.72	0.04	0.05
* 870414									
0130082	870414	0.00	0.003	0.006	-0.01	0.10	0.81	0.02	0.03
0130082	870414	10.00	0.004	0.007	-0.01	0.10	0.78	0.03	0.03
0130082	870414	20.00	0.003	0.007	-0.01	0.11	0.79	0.02	0.03
0130082	870414	30.00	0.003	0.007	-0.01	0.11	0.76	0.03	0.04
0130082	870414	40.00	0.005	0.011	-0.01	0.09	0.85	0.05	0.06
0130082	870414	60.00	0.005	0.009	-0.01	0.15	0.81	0.05	0.05
* 870708									
0130082	870708	0.00	-9.999	0.002	-9.99	0.03	0.65	-9.99	-0.01
0130082	870708	10.00	-9.999	0.003	-9.99	0.03	0.61	-9.99	-0.01
0130082	870708	20.00	-9.999	0.005	-9.99	0.11	0.64	-9.99	-0.01
0130082	870708	30.00	-9.999	0.005	-9.99	0.05	0.69	-9.99	0.01
0130082	870708	40.00	-9.999	0.005	-9.99	0.05	0.74	-9.99	0.03
0130082	870708	60.00	-9.999	0.006	-9.99	0.07	0.80	-9.99	0.04
* 870909									
0130082	870909	0.00	0.001	0.003	-0.01	-0.01	0.88	-0.01	-0.01
0130082	870909	10.00	0.001	0.004	-0.01	0.01	0.79	-0.01	-0.01

BUTTLE LAKE WATER QUALITY DATA

SITE	DATE y m d	DEPTH m	CU D mg/l	CU T mg/l	FE D mg/l	FE T mg/l	MG T mg/l	MN D mg/l	MN T mg/l
0130082	870909	20.00	0.001	0.004	-0.01	0.01	0.75	-0.01	-0.01
0130082	870909	30.00	0.001	0.004	-0.01	0.01	0.92	-0.01	-0.01
0130082	870909	40.00	0.002	0.007	0.02	0.02	0.84	0.02	0.03
0130082	870909	60.00	0.003	0.007	-0.01	0.03	0.80	0.02	0.03
* 871109									
0130082	871109	0.00	0.002	0.005	0.02	0.07	0.75	0.02	0.02
* 880119									
0130082	880119	0.00	0.002	0.005	-0.01	0.08	0.71	0.02	0.03
* 880308									
0130082	880308	0.00	0.005	0.006	0.03	0.12	0.76	0.02	0.03
* 880510									
0130082	880510	0.00	0.002	0.002	0.01	0.23	0.74	-0.01	0.01
0130082	880510	10.00	0.001	0.001	-0.01	0.09	0.77	-0.01	-0.01
0130082	880510	20.00	0.002	0.002	-0.01	0.09	0.73	-0.01	0.02
0130082	880510	30.00	0.003	0.004	0.01	0.08	0.81	0.02	0.03
0130082	880510	40.00	0.002	0.002	-0.01	0.08	0.78	0.01	0.02
0130082	880510	60.00	0.004	0.004	0.01	0.13	0.87	0.02	0.03
* 880706									
0130082	880706	0.00	0.002	0.003	-0.01	0.06	0.77	-0.01	-0.01
0130082	880706	10.00	0.001	0.003	-0.01	0.04	0.68	-0.01	-0.01
0130082	880706	20.00	0.001	0.002	-0.01	0.04	0.63	-0.01	-0.01
0130082	880706	30.00	0.002	0.003	-0.01	0.09	0.75	-0.01	0.01
0130082	880706	40.00	0.002	0.003	0.01	0.03	0.78	-0.01	0.02
0130082	880706	60.00	0.002	0.004	0.01	0.07	0.83	-0.01	0.02
* 880913									
0130082	880913	0.00	0.003	0.003	0.01	0.04	0.89	-0.01	-0.01
0130082	880913	10.00	-0.001	0.004	0.01	0.04	0.81	-0.01	-0.01
0130082	880913	20.00	-0.001	0.003	0.01	0.03	0.81	-0.01	-0.01
0130082	880913	30.00	0.004	0.004	0.01	0.01	0.78	-0.01	-0.01
0130082	880913	40.00	0.002	0.003	-0.01	0.03	0.75	-0.01	-0.01
0130082	880913	60.00	0.002	0.004	-0.01	-0.01	0.81	-0.01	0.01
* 881108									
0130082	881108	0.00	-0.001	0.001	0.02	0.04	0.65	-0.01	-0.01
0130082	881108	10.00	0.002	0.002	0.02	0.07	0.62	-0.01	-0.01
0130082	881108	20.00	0.005	0.006	0.03	0.16	0.57	0.01	0.02
0130082	881108	30.00	0.003	0.006	0.02	0.15	0.70	-0.01	0.01
0130082	881108	40.00	0.002	0.003	0.02	0.05	0.76	-0.01	-0.01
0130082	881108	60.00	0.002	0.003	0.02	0.05	0.78	-0.01	0.01

BUTTLE LAKE WATER QUALITY DATA

SITE	DATE y m d	DEPTH m	CU D mg/l	CU T mg/l	FE D mg/l	FE T mg/l	MG T mg/l	MN D mg/l	MN T mg/l
* 890118									
0130082	890118	0.00	-0.001	-0.001	-0.01	0.05	0.80	-0.01	0.01
0130082	890118	10.00	0.002	0.002	-0.01	0.06	0.77	-0.01	0.01
0130082	890118	20.00	0.001	0.001	0.01	0.02	0.73	-0.01	0.01
0130082	890118	30.00	0.002	0.003	-0.01	0.02	0.73	-0.01	0.01
0130082	890118	40.00	0.002	0.002	-0.01	0.04	0.74	-0.01	0.01
0130082	890118	50.00	0.001	0.002	-0.01	0.05	0.74	-0.01	0.01
* 890307									
0130082	890307	0.00	0.001	0.004	0.04	0.11	0.78	0.04	0.04
* 890613									
0130082	890613	0.00	0.002	0.002	-0.01	-0.01	0.65	-0.01	-0.01
0130082	890613	10.00	0.002	0.002	-0.01	0.02	0.59	-0.01	-0.01
0130082	890613	20.00	0.002	0.002	0.01	0.02	0.72	-0.01	-0.01
0130082	890613	30.00	0.002	0.003	0.01	0.04	0.74	-0.01	-0.01
0130082	890613	40.00	0.001	0.013	0.02	0.04	0.75	-0.01	0.01
0130082	890613	60.00	0.002	0.002	0.03	0.03	0.80	0.02	0.02
* 890822									
0130082	890822	0.00	0.001	0.001	-0.01	0.02	0.69	-0.01	0.03
0130082	890822	10.00	-0.001	0.001	0.01	0.02	0.67	-0.01	0.03
0130082	890822	20.00	-0.001	-0.001	0.02	0.02	0.70	-0.01	-0.01
0130082	890822	30.00	0.001	0.001	-0.01	0.02	0.78	-0.01	0.01
0130082	890822	40.00	0.001	0.002	-0.01	0.03	0.75	-0.01	0.03
0130082	890822	60.00	0.001	0.001	-0.01	0.03	0.77	-0.01	0.02
* 891024									
0130082	891024	0.00	0.002	0.002	0.02	0.03	0.71	-0.01	-0.01
0130082	891024	10.00	0.003	0.004	0.03	0.11	0.62	-0.01	0.01
0130082	891024	20.00	0.002	0.002	0.08	0.11	0.57	0.01	0.01
0130082	891024	30.00	0.002	0.005	0.03	0.14	0.74	-0.01	-0.01
0130082	891024	40.00	0.004	0.005	0.03	0.05	0.74	-0.01	-0.01
0130082	891024	60.00	-0.001	0.005	0.04	0.04	0.76	-0.01	-0.01
* 891212									
0130082	891212	0.00	0.003	0.009	0.02	0.04	0.70	-0.01	-0.01
0130082	891212	10.00	0.002	0.002	0.02	0.04	0.70	-0.01	-0.01
0130082	891212	20.00	0.003	0.006	0.03	0.08	0.65	-0.01	0.01
0130082	891212	30.00	0.002	0.003	0.02	0.05	0.70	-0.01	-0.01
0130082	891212	40.00	0.004	0.004	0.01	0.06	0.66	0.01	0.01
0130082	891212	60.00	0.002	0.004	0.01	0.03	0.81	-0.01	-0.01

```
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                          BUTTLE LAKE WATER QUALITY DATA

SITE      DATE    DEPTH    PB D    PB T    ZN D    ZN T
          y m d       m    mg/l    mg/l    mg/l    mg/l
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** 0130080

*  810217
 0130080 810217  0.00 -0.001 -0.001  0.100  0.100
 0130080 810217  5.00 -0.001 -0.001  0.110  0.120

*  810312
 0130080 810312  0.00 -9.999 -0.001 -9.999  0.130

*  810414
 0130080 810414  0.00 -9.999 -0.001 -9.999  0.120

*  810624
 0130080 810624  0.00 -0.001  0.005  0.100  0.100

*  810819
 0130080 810819  0.00 -0.001 -0.001  0.040  0.040

*  811117
 0130080 811117  0.00  0.001  0.001  0.070  0.080

*  820223
 0130080 820223  0.00 -0.001  0.001 -9.999 -9.999

*  820615
 0130080 820615  0.00 -0.001 -0.001  0.030  0.030

*  820818
 0130080 820818  0.00 -0.001 -0.001  0.040  0.050

*  821208
 0130080 821208  0.00 -0.001  0.001  0.070  0.080

*  830324
 0130080 830324  0.00 -9.999 -9.999 -9.999 -9.999

*  830426
 0130080 830426  0.00 -0.001 -0.001  0.080  0.090

*  830517
 0130080 830517  0.00 -0.001 -0.001  0.070  0.100

*  830616
 0130080 830616  0.00  0.011  0.014 -0.010 -0.010
```

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                       BUTTLE LAKE WATER QUALITY DATA

SITE      DATE    DEPTH    PB D     PB T    ZN D    ZN T
          y m d       m    mg/l     mg/l    mg/l    mg/l
------- ------  -----  ------  ------  ------  ------


*  830629
0130080 830629  0.00 -0.001   0.002   0.040   0.050
0130080 830629  1.00  0.001   0.002   0.030   0.050

*  830719
0130080 830719  0.00 -0.001  -0.001   0.040   0.040

*  830811
0130080 830811  0.00 -0.001   0.002   0.040   0.040

*  830826
0130080 830826  0.00 -0.001  -0.001   0.020   0.030

*  831027
0130080 831027  0.00  0.001   0.001   0.030   0.050

*  831116
0130080 831116  0.00 -0.001  -0.001   0.030   0.040

*  831215
0130080 831215  0.50 -0.001   0.001   0.050   0.060

*  840104
0130080 840104  0.50 -0.001  -0.001   0.060   0.070

*  840119
0130080 840119  0.50 -0.001  -0.001   0.060   0.070

*  840229
0130080 840229  0.50 -0.001  -0.001   0.050   0.050

*  840327
0130080 840327  0.00 -0.001   0.001   0.060   0.060

*  840524
0130080 840524  0.00 -0.100  -0.100   0.050   0.070

*  840619
0130080 840619  0.00 -0.001   0.001   0.030   0.050

*  840711
0130080 840711  0.00 -0.001  -0.001   0.030   0.060

*  840725
0130080 840725  0.00 -0.001  -0.001   0.030   0.030
```

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                           BUTTLE LAKE WATER QUALITY DATA

SITE    DATE   DEPTH   PB D   PB T   ZN D   ZN T
        y m d      m   mg/l   mg/l   mg/l   mg/l
------- ------ ----- ------ ------ ------ ------


* 841002
0130080 841002  0.00 -0.001  0.001  0.030  0.040

* 841010
0130080 841010  0.00 -0.001 -0.001  0.010  0.020

* 841211
0130080 841211  0.00 -0.001 -0.001  0.040  0.050

* 850128
0130080 850128  0.00 -0.100 -0.100  0.050  0.050

* 850410
0130080 850410  0.00 -0.100 -0.100  0.050  0.050

* 850709
0130080 850709  0.00 -0.001 -0.001  0.030  0.030

* 850725
0130080 850725  0.00 -0.100 -0.100  0.020  0.090

* 850909
0130080 850909  0.00 -0.001 -0.001 -0.030 -0.030

* 851024
0130080 851024  0.00 -0.100  0.002  0.030  0.040

* 851204
0130080 851204  0.00 -9.999  0.002 -9.999  0.040

* 860206
0130080 860206  0.00 -0.001  0.002  0.040  0.040

* 860225
0130080 860225  0.00 -9.999 -0.001 -9.999  0.020

* 860319
0130080 860319  0.00  0.001  0.003  0.040  0.040

* 860430
0130080 860430  0.00 -0.001  0.001  0.030  0.030

* 860603
0130080 860603  0.00  0.001  0.002  0.040  0.040
```

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                        BUTTLE LAKE WATER QUALITY DATA

SITE     DATE    DEPTH    PB D    PB T    ZN D    ZN T
         y m d       m    mg/l    mg/l    mg/l    mg/l
------- ------ ----- ------ ------ ------ ------


* 870127
0130080 870127  0.00 -9.999  0.002 -9.999  0.030

* 870218
0130080 870218  0.00  0.001  0.005  0.030  0.030

* 870408
0130080 870408  0.00 -9.999  0.002 -9.999  0.030

* 870505
0130080 870505  0.00 -9.999  0.003 -9.999  0.030

* 870603
0130080 870603  0.00 -9.999  0.004 -9.999  0.030

* 870727
0130080 870727  0.00 -9.999  0.001 -9.999  0.020

* 871015
0130080 871015  0.00 -0.001 -0.001  0.020  0.025

* 871118
0130080 871118  0.00 -9.999  0.003 -9.999  0.017

* 871208
0130080 871208  0.00 -0.001  0.002  0.016  0.030

* 880118
0130080 880118  0.00 -9.999  0.002 -9.999  0.050

* 880119
0130080 880119  0.00 -9.999  0.006 -9.999  0.030

* 880208
0130080 880208  0.00 -9.999  0.002 -9.999  0.030

* 880303
0130080 880303  0.00 -9.999  0.001 -9.999  0.032

* 880413
0130080 880413  0.00 -0.001 -0.001  0.030  0.030

* 880420
0130080 880420  0.00 -9.999 -0.001 -9.999  0.015
```

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                        BUTTLE LAKE WATER QUALITY DATA

SITE       DATE    DEPTH    PB D     PB T     ZN D     ZN T
           y m d       m    mg/l     mg/l     mg/l     mg/l
------- ------ ----- ------ ------ ------ ------


*  880518
 0130080 880518   0.00 -9.999 -0.100 -9.999  0.030

*  880615
 0130080 880615   0.00 -9.999  0.002 -9.999  0.050

*  880719
 0130080 880719   0.00 -9.999 -0.001 -9.999  0.016

*  881103
 0130080 881103   0.00 -9.999 -0.001 -9.999  0.010

*  881221
 0130080 881221   0.00 -9.999 -0.001 -9.999  0.016

*  890112
 0130080 890112   0.00 -9.999 -9.999 -9.999  0.055

*  890206
 0130080 890206   0.00 -9.999  0.001 -9.999  0.029

*  890307
 0130080 890307   0.00  0.001  0.001  0.020  0.023

*  890511
 0130080 890511   0.50  0.001  0.002  0.019  0.021

*  890614
 0130080 890614   0.00  0.001 -0.001  0.013  0.018

*  890710
 0130080 890710   0.00 -9.999 -0.100 -9.999  0.014

*  890814
 0130080 890814   0.00 -9.999 -0.100 -9.999  0.020

*  890907
 0130080 890907   0.00 -9.999  0.001 -9.999  0.010

*  891024
 0130080 891024   0.00  0.001  0.003  0.009  0.013

*  891207
 0130080 891207   0.00 -9.999 -9.999 -9.999  0.020
```

BUTTLE LAKE WATER QUALITY DATA

```
 SITE     DATE    DEPTH   PB D    PB T    ZN D    ZN T
          y m d       m   mg/l    mg/l    mg/l    mg/l
 ------- ------ ----- ------ ------ ------ ------


*  891212
 0130080 891212  0.00  0.001  0.002  0.014  0.014

*  900227
 0130080 900227  0.00 -9.999 -9.999 -9.999 -9.999

**  0130082

*  810416
 0130082 810416  3.00  0.007 -9.999  0.230 -9.999
 0130082 810416 15.00  0.006 -9.999  0.170 -9.999
 0130082 810416 30.00  0.009 -9.999  0.280 -9.999
 0130082 810416 45.00  0.022 -9.999  0.370 -9.999

*  810513
 0130082 810513  3.00  0.003 -9.999  0.150 -9.999
 0130082 810513 15.00 -0.001 -9.999  0.210 -9.999
 0130082 810513 30.00  0.005 -9.999  0.250 -9.999
 0130082 810513 50.00  0.003 -9.999  0.210 -9.999

*  810608
 0130082 810608  3.00  0.002 -9.999  0.160 -9.999
 0130082 810608 15.00  0.009 -9.999  0.180 -9.999
 0130082 810608 30.00  0.008 -9.999  0.230 -9.999
 0130082 810608 50.00  0.007 -9.999  0.250 -9.999

*  810714
 0130082 810714  3.00 -0.001 -9.999  0.130 -9.999
 0130082 810714  3.10  0.010 -9.999  0.120 -9.999
 0130082 810714 15.00 -0.001 -9.999  0.130 -9.999
 0130082 810714 30.00  0.014 -9.999  0.200 -9.999
 0130082 810714 50.00  0.006 -9.999  0.240 -9.999

*  810812
 0130082 810812  3.00 -0.001 -9.999  0.080 -9.999
 0130082 810812  3.10 -0.001 -9.999  0.090 -9.999
 0130082 810812 15.00 -0.001 -9.999  0.130 -9.999
 0130082 810812 30.00  0.002 -9.999  0.160 -9.999
 0130082 810812 50.00  0.011 -9.999  0.230 -9.999

*  810908
 0130082 810908  3.00 -0.001 -9.999  0.110 -9.999
 0130082 810908  3.10 -0.001 -9.999  0.100 -9.999
 0130082 810908 15.00 -0.001 -9.999  0.130 -9.999
 0130082 810908 30.00 -0.001 -9.999  0.160 -9.999
 0130082 810908 50.00  0.010 -9.999  0.200 -9.999
```

BUTTLE LAKE WATER QUALITY DATA

```
SITE     DATE    DEPTH    PB D    PB T    ZN D    ZN T
         y m d       m    mg/l    mg/l    mg/l    mg/l
------- ------ ----- ------ ------ ------ ------


* 811020
 0130082 811020  3.00 -0.001  0.001  0.100  0.120
 0130082 811020 15.00 -0.001  0.001  0.180  0.210
 0130082 811020 30.00  0.003  0.005  0.170  0.190
 0130082 811020 50.00  0.008  0.025  0.210  0.290

* 811118
 0130082 811118  3.00 -0.001 -9.999  0.130 -9.999
 0130082 811118  3.10 -0.001 -9.999  0.130 -9.999
 0130082 811118 15.00 -0.001 -9.999  0.190 -9.999
 0130082 811118 30.00 -0.001 -9.999  0.190 -9.999
 0130082 811118 50.00  0.003 -9.999  0.160 -9.999

* 820119
 0130082 820119 20.00 -9.999 -9.999  0.230  0.230

* 820215
 0130082 820215  3.00 -0.001  0.004 -9.999 -9.999
 0130082 820215  3.10  0.001 -9.999 -9.999 -9.999
 0130082 820215 15.00  0.001  0.006 -9.999 -9.999
 0130082 820215 30.00  0.001  0.006 -9.999 -9.999
 0130082 820215 50.00  0.005  0.055 -9.999 -9.999

* 820614
 0130082 820614  0.50 -9.999 -0.001 -9.999 -9.999

* 830324
 0130082 830324  0.00 -9.999 -9.999 -9.999 -9.999

* 830426
 0130082 830426  0.00 -9.999  0.001 -9.999  0.080

* 830601
 0130082 830601  0.00 -9.999 -0.001 -9.999  0.050

* 830720
 0130082 830720  0.00 -9.999  0.003 -9.999  0.040

* 830822
 0130082 830822  0.00 -9.999  0.001 -9.999  0.018
 0130082 830822 20.00 -9.999  0.001 -9.999  0.070
 0130082 830822 40.00 -9.999  0.021 -9.999  0.250
 0130082 830822 100.0 -9.999  0.260 -9.999  1.450
```

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                           BUTTLE LAKE WATER QUALITY DATA

SITE     DATE   DEPTH   PB D   PB T   ZN D   ZN T
         y m d      m   mg/l   mg/l   mg/l   mg/l
------- ------ ----- ------ ------ ------ ------


* 831025
0130082 831025  0.00 -9.999 -0.001 -9.999  0.040

* 831214
0130082 831214  0.00 -9.999  0.003 -9.999  0.120
0130082 831214 20.00 -9.999 -0.100 -9.999  0.130
0130082 831214 40.00 -9.999 -0.100 -9.999  0.130
0130082 831214 132.0 -9.999 -0.100 -9.999  0.180

* 840214
0130082 840214  0.00 -9.999 -0.100 -9.999  0.140
0130082 840214 20.00 -9.999 -0.100 -9.999  0.150

* 840327
0130082 840327  0.00 -9.999 -0.001 -9.999  0.110
0130082 840327 20.00 -9.999  0.001 -9.999  0.150
0130082 840327 40.00 -9.999  0.070 -9.999  0.600

* 840501
0130082 840501  0.00 -9.999  0.002 -9.999  0.120
0130082 840501 20.00 -9.999  0.003 -9.999  0.160
0130082 840501 40.00 -9.999  0.006 -9.999  0.180
0130082 840501 65.00 -9.999  0.011 -9.999  0.230

* 840619
0130082 840619  0.00 -9.999 -0.001 -9.999  0.050
0130082 840619 20.00 -9.999 -0.001 -9.999  0.050
0130082 840619 40.00 -9.999  0.011 -9.999  0.210
0130082 840619 69.00 -9.999  0.150 -9.999  1.330

* 840725
0130082 840725  0.00 -9.999 -0.001 -9.999  0.030
0130082 840725 20.00 -9.999 -0.001 -9.999  0.050

* 840822
0130082 840822  0.00 -9.999 -0.001 -9.999  0.010
0130082 840822 20.00 -9.999 -0.001 -9.999  0.040
0130082 840822 40.00 -9.990 -0.001 -9.999  0.070
0130082 840822 65.00 -9.999 -0.001 -9.999  0.150

* 841002
0130082 841002  0.00 -9.999  0.001 -9.999  0.030
0130082 841002 20.00 -9.999  0.004 -9.999  0.070
0130082 841002 40.00 -9.999  0.002 -9.999  0.130
0130082 841002 60.00 -9.999  0.003 -9.999  0.170
```

```
                                 BUTTLE LAKE WATER QUALITY DATA

SITE     DATE    DEPTH    PB D    PB T    ZN D    ZN T
         y m d       m    mg/l    mg/l    mg/l    mg/l
------- ------ ----- ------ ------ ------ ------


* 841211
0130082 841211  0.00 -9.999 -0.100 -9.999  0.060
0130082 841211 20.00 -9.999 -0.100 -9.999  0.090
0130082 841211 40.00 -9.999 -0.100 -9.999  0.080
0130082 841211 60.00 -9.999 -0.100 -9.999  0.110

* 850219
0130082 850219  0.00 -9.999 -0.001 -9.999  0.070
0130082 850219 20.00 -9.999  0.002 -9.999  0.090
0130082 850219 40.00 -9.999 -0.001 -9.999  0.090
0130082 850219 65.00 -9.999  0.002 -9.999  0.110

* 850430
0130082 850430  0.00 -9.999 -0.100 -9.999  0.070
0130082 850430 20.00 -9.999 -0.100 -9.999  0.090
0130082 850430 40.00 -9.999 -0.100 -9.999  0.090
0130082 850430 60.00 -9.999 -0.100 -9.999  0.110

* 850604
0130082 850604  0.00 -9.999 -0.001 -9.999  0.050
0130082 850604 20.00 -9.999  0.004 -9.999  0.060
0130082 850604 40.00 -9.999 -0.001 -9.999  0.090
0130082 850604 60.00 -9.999 -0.001 -9.999  0.110

* 850709
0130082 850709  0.00 -9.999 -0.100 -9.999  0.050
0130082 850709 20.00 -9.999 -0.100 -9.999  0.070
0130082 850709 40.00 -9.999 -0.100 -9.999  0.100
0130082 850709 60.00 -9.999 -0.100 -9.999  0.090
0130082 850709 100.0 -9.999 -0.100 -9.999  0.090

* 850813
0130082 850813  0.00 -9.999 -0.001 -9.999  0.040
0130082 850813 20.00 -9.999 -0.001 -9.999  0.050
0130082 850813 40.00 -9.999 -0.001 -9.999  0.070
0130082 850813 60.00 -9.999 -0.001 -9.999  0.080

* 850917
0130082 850917  0.00 -9.999 -0.001 -9.999  0.030
0130082 850917 20.00 -9.999 -0.001 -9.999  0.050
0130082 850917 40.00 -9.999 -0.001 -9.999  0.070
0130082 850917 60.00 -9.999 -0.001 -9.999  0.080

* 851022
0130082 851022  0.00 -9.999  0.001 -9.999  0.030
0130082 851022 20.00 -9.999  0.006 -9.999  0.080
```

BUTTLE LAKE WATER QUALITY DATA

```
SITE     DATE    DEPTH   PB D    PB T    ZN D    ZN T
         y m d       m   mg/l    mg/l    mg/l    mg/l
------- ------ ----- ------ ------ ------ ------


0130082 851022 40.00 -9.999  0.002 -9.999  0.070
0130082 851022 60.00 -9.999  0.002 -9.999  0.090

*  851212
0130082 851212  0.00 -9.999  0.001 -9.999  0.050
0130082 851212 20.00 -9.999  0.002 -9.999  0.060
0130082 851212 40.00 -9.999 -0.001 -9.999  0.050
0130082 851212 60.00 -9.999 -0.001 -9.999  0.070

*  860211
0130082 860211  0.00 -0.001  0.004  0.040  0.040
0130082 860211 10.00 -0.001  0.014  0.040  0.040
0130082 860211 20.00 -0.001  0.007  0.060  0.060
0130082 860211 30.00 -0.001  0.002  0.070  0.070
0130082 860211 40.00 -0.001  0.004  0.080  0.080
0130082 860211 60.00 -0.001  0.009  0.090  0.090

*  860311
0130082 860311  0.00 -0.001 -0.001  0.040  0.050
0130082 860311 10.00 -0.001  0.003  0.050  0.050
0130082 860311 20.00 -0.001 -0.001  0.050  0.060
0130082 860311 30.00 -0.001 -0.001  0.060  0.060
0130082 860311 40.00 -0.001 -0.001  0.060  0.070
0130082 860311 60.00 -0.001  0.002  0.080  0.080

*  860415
0130082 860415  0.00 -0.001  0.001  0.040  0.050
0130082 860415 10.00 -0.001 -0.001  0.050  0.050
0130082 860415 20.00 -0.001  0.003  0.050  0.060
0130082 860415 30.00 -0.001  0.002  0.060  0.070
0130082 860415 40.00 -0.001  0.001  0.060  0.070
0130082 860415 60.00 -0.001  0.003  0.070  0.080

*  860512
0130082 860512  0.00 -0.001 -0.001  0.040  0.050
0130082 860512 10.00 -0.001 -0.001  0.040  0.050
0130082 860512 20.00 -0.001 -0.001  0.050  0.050
0130082 860512 30.00 -0.001 -0.001  0.050  0.060
0130082 860512 40.00 -0.001  0.002  0.060  0.070
0130082 860512 60.00 -0.001  0.001  0.040  0.050

*  860610
0130082 860610  0.00 -0.001  0.001  0.020  0.030
0130082 860610 10.00 -0.001 -0.001  0.020  0.020
0130082 860610 20.00 -0.001  0.008  0.020  0.020
0130082 860610 30.00 -0.001 -0.001  0.040  0.040
```

BUTTLE LAKE WATER QUALITY DATA

SITE	DATE y m d	DEPTH m	PB D mg/l	PB T mg/l	ZN D mg/l	ZN T mg/l
0130082	860610	40.00	-0.001	-0.001	0.060	0.060
0130082	860610	60.00	-0.001	0.001	0.060	0.060
* 860708						
0130082	860708	0.00	-0.001	0.001	0.020	0.020
0130082	860708	10.00	0.001	0.002	0.020	0.030
0130082	860708	20.00	-0.001	0.003	0.030	0.030
0130082	860708	30.00	-0.001	0.003	0.050	0.050
0130082	860708	40.00	-0.001	0.004	0.050	0.050
0130082	860708	60.00	-0.001	0.003	0.060	0.070
* 860812						
0130082	860812	0.00	-0.001	-0.001	0.015	0.020
0130082	860812	10.00	-0.001	-0.001	0.021	0.030
0130082	860812	20.00	-0.001	-0.001	0.030	0.040
0130082	860812	30.00	-0.001	-0.001	0.030	0.040
0130082	860812	40.00	-0.001	0.002	0.060	0.060
0130082	860812	60.00	-0.001	0.002	0.060	0.070
* 870204						
0130082	870204	0.00	-0.001	-0.001	0.050	0.070
0130082	870204	10.00	-0.001	-0.001	0.060	0.070
0130082	870204	20.00	-0.001	0.002	0.070	0.080
0130082	870204	30.00	-0.001	0.001	0.090	0.110
0130082	870204	40.00	0.001	0.001	0.090	0.090
0130082	870204	60.00	-0.001	0.001	0.080	0.090
* 870414						
0130082	870414	0.00	0.001	0.009	0.070	0.080
0130082	870414	10.00	0.001	0.007	0.080	0.080
0130082	870414	20.00	0.001	0.004	0.070	0.070
0130082	870414	30.00	0.001	0.005	0.080	0.080
0130082	870414	40.00	0.001	0.008	0.110	0.120
0130082	870414	60.00	0.001	0.004	0.120	0.120
* 870708						
0130082	870708	0.00	-9.999	0.002	-9.999	0.020
0130082	870708	10.00	-9.999	0.002	-9.999	0.030
0130082	870708	20.00	-9.999	0.003	-9.999	0.040
0130082	870708	30.00	-9.999	0.008	-9.999	0.060
0130082	870708	40.00	-9.999	0.005	-9.999	0.090
0130082	870708	60.00	-9.999	0.003	-9.999	0.100
* 870909						
0130082	870909	0.00	0.001	0.001	0.030	0.030
0130082	870909	10.00	-0.001	0.001	0.030	0.030

```
                        BUTTLE LAKE WATER QUALITY DATA

SITE     DATE   DEPTH   PB D    PB T    ZN D    ZN T
         y m d      m   mg/l    mg/l    mg/l    mg/l
------- ------ ----- ------ ------ ------ ------


0130082 870909 20.00 -0.001  0.001  0.040  0.040
0130082 870909 30.00 -0.001  0.001  0.030  0.030
0130082 870909 40.00 -0.001  0.001  0.080  0.090
0130082 870909 60.00  0.001  0.001  0.090  0.090

*  871109
0130082 871109  0.00 -0.001  0.002  0.030  0.040

*  880119
0130082 880119  0.00  0.001  0.002  0.050  0.060

*  880308
0130082 880308  0.00  0.001 -9.999  0.050  0.060

*  880510
0130082 880510  0.00 -0.001 -0.001  0.030  0.030
0130082 880510 10.00 -0.001 -0.001  0.030  0.040
0130082 880510 20.00 -0.001 -0.001  0.040  0.050
0130082 880510 30.00 -0.001 -0.001  0.070  0.080
0130082 880510 40.00 -0.001  0.002  0.050  0.060
0130082 880510 60.00 -0.001  0.002  0.090  0.090

*  880706
0130082 880706  0.00 -0.001 -0.001  0.014  0.016
0130082 880706 10.00 -0.001  0.001  0.020  0.030
0130082 880706 20.00 -0.001 -0.001  0.030  0.040
0130082 880706 30.00 -0.001 -0.001  0.040  0.060
0130082 880706 40.00 -0.001 -0.001  0.050  0.070
0130082 880706 60.00 -0.001 -0.001  0.070  0.090

*  880913
0130082 880913  0.00 -0.001 -0.001 -0.005  0.012
0130082 880913 10.00 -0.001  0.002  0.030  0.030
0130082 880913 20.00 -0.001  0.001  0.030  0.040
0130082 880913 30.00 -0.001  0.001  0.050  0.050
0130082 880913 40.00 -0.001  0.001  0.050  0.060
0130082 880913 60.00 -0.001  0.001  0.070  0.080

*  881108
0130082 881108  0.00 -0.001 -0.001  0.010  0.011
0130082 881108 10.00 -0.001 -0.001  0.025  0.030
0130082 881108 20.00 -0.001 -0.001  0.040  0.040
0130082 881108 30.00 -0.001 -0.001  0.040  0.050
0130082 881108 40.00 -0.001 -0.001  0.050  0.050
0130082 881108 60.00 -0.001 -0.001  0.060  0.070
```

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                                 BUTTLE LAKE WATER QUALITY DATA

SITE     DATE    DEPTH    PB D    PB T    ZN D    ZN T
         y m d       m    mg/l    mg/l    mg/l    mg/l
------- ------  -----  ------  ------  ------  ------


* 890118
0130082 890118   0.00 -0.001  -0.001   0.030   0.040
0130082 890118  10.00 -0.001   0.001   0.030   0.050
0130082 890118  20.00 -0.001  -0.001   0.040   0.040
0130082 890118  30.00 -0.001  -0.001   0.040   0.040
0130082 890118  40.00 -0.001  -0.001   0.040   0.040
0130082 890118  50.00 -0.001  -0.001   0.040   0.040

* 890307
0130082 890307   0.00 -0.001  -0.001   0.040   0.040

* 890613
0130082 890613   0.00 -0.001  -0.001   0.013   0.018
0130082 890613  10.00 -0.001  -0.001   0.013   0.019
0130082 890613  20.00 -0.001  -0.001   0.026   0.030
0130082 890613  30.00 -0.001   0.001   0.030   0.030
0130082 890613  40.00 -0.001  -0.001   0.040   0.040
0130082 890613  60.00 -0.001  -0.001   0.040   0.040

* 890822
0130082 890822   0.00 -0.001  -0.001   0.008   0.012
0130082 890822  10.00 -0.001  -0.001   0.055   0.078
0130082 890822  20.00 -0.001  -0.001   0.020   0.020
0130082 890822  30.00 -0.001  -0.001   0.030   0.030
0130082 890822  40.00 -0.001   0.001   0.030   0.040
0130082 890822  60.00 -0.001  -0.001   0.040   0.040

* 891024
0130082 891024   0.00 -0.001  -0.001   0.014   0.019
0130082 891024  10.00 -0.001  -0.001   0.017   0.020
0130082 891024  20.00  0.001   0.001   0.020   0.030
0130082 891024  30.00 -0.001  -0.001   0.030   0.040
0130082 891024  40.00 -0.001  -0.001   0.040   0.040
0130082 891024  60.00 -0.001   0.001   0.040   0.050

* 891212
0130082 891212   0.00 -0.001   0.001   0.030   0.030
0130082 891212  10.00 -0.001  -0.001   0.028   0.030
0130082 891212  20.00 -0.001   0.002   0.030   0.040
0130082 891212  30.00 -0.001  -0.001   0.040   0.040
0130082 891212  40.00 -0.001  -0.001   0.040   0.050
0130082 891212  60.00 -0.001   0.002   0.040   0.050
```

Appendix C

Historical Water Quality Profiles for Buttle Lake

WMB - SEAM DATA

(Negative 9(s) values indicate missing data; other negative values indicate less than detection limits)

Rescan

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                         BUTTLE LAKE WATER QUALITY PROFILES
                                  FOR SITE 0130082

SITE     DATE   TIME    DEPTH      PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
         y m d              m           uS/cm    deg C    mg/l           m
------- ------ ------ ----- ----- -------- -------- ------- ----------


**  810218
 0130082 810218 1530    0.00  6.89       -99     4.80   11.88        1.5
 0130082 810218 1530    5.00  6.90       -99     4.80   11.50       -9.9
 0130082 810218 1530   10.00  6.88       -99     4.80   11.50       -9.9
 0130082 810218 1530   15.00  6.88       -99     4.80   11.50       -9.9
 0130082 810218 1530   20.00  6.87       -99     4.90   11.50       -9.9
 0130082 810218 1530   25.00  6.89       -99     4.90   11.50       -9.9
 0130082 810218 1530   30.00  6.89       -99     4.80   -9.99       -9.9
 0130082 810218 1530   35.00  6.89       -99     4.90   -9.99       -9.9
 0130082 810218 1530   40.00  6.90       -99     4.90   -9.99       -9.9

**  810310
 0130082 810310 1100    0.00  6.56       -99     6.10   11.65        3.2
 0130082 810310 1100    5.00  6.63       -99     5.40   11.51       -9.9
 0130082 810310 1100   10.00  6.62       -99     4.90   11.61       -9.9
 0130082 810310 1100   15.00  6.60       -99     4.60   11.73       -9.9
 0130082 810310 1100   20.00  6.58       -99     4.50   11.71       -9.9
 0130082 810310 1100   25.00  6.56       -99     4.50   11.69       -9.9
 0130082 810310 1100   30.00  6.55       -99     4.60   11.62       -9.9
 0130082 810310 1100   35.00  6.55       -99     4.60   11.68       -9.9
 0130082 810310 1100   40.00  6.56       -99     4.60   11.65       -9.9

**  810416
 0130082 810416 1030    0.00  7.39       -99     6.10   11.46        2.8
 0130082 810416 1030    5.00  7.38       -99     5.70   11.66       -9.9
 0130082 810416 1030   10.00  7.35       -99     5.50   11.69       -9.9
 0130082 810416 1030   15.00  7.33       -99     5.50   11.71       -9.9
 0130082 810416 1030   20.00  7.32       -99     5.30   11.63       -9.9
 0130082 810416 1030   25.00  7.31       -99     5.20   11.53       -9.9
 0130082 810416 1030   30.00  7.31       -99     5.00   11.35       -9.9
 0130082 810416 1030   35.00  7.30       -99     5.00   11.32       -9.9

**  810513
 0130082 810513 0948    0.00  6.54       -99    10.90   10.61       -9.9
 0130082 810513 0948    5.00  6.79       -99     9.00   10.62       -9.9
 0130082 810513 0948   10.00  6.98       -99     7.70   11.05       -9.9
 0130082 810513 0948   15.00  7.02       -99     7.20   11.05       -9.9
 0130082 810513 0948   20.00  7.07       -99     6.50   10.98       -9.9
 0130082 810513 0948   25.00  7.13       -99     5.80   10.91       -9.9
 0130082 810513 0948   30.00  7.19       -99     5.60   10.98       -9.9
 0130082 810513 0948   35.00  7.24       -99     5.40   10.92       -9.9
 0130082 810513 0948   40.00  7.29       -99     5.30   10.89       -9.9
 0130082 810513 0948   45.00  7.33       -99     5.20   10.86       -9.9
 0130082 810513 0948   50.00  7.37       -99     5.20   10.86       -9.9
 0130082 810513 0948   55.00  7.41       -99     5.20   10.85       -9.9
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                    BUTTLE LAKE WATER QUALITY PROFILES
                             FOR SITE 0130082

SITE     DATE    TIME    DEPTH      PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
         y m d               m            uS/cm    deg C    mg/l          m
------- ------ ------ ----- ----- -------- -------- ------- ----------


** 810527
0130082 810527 0955    0.00  7.20      -99     9.50   11.21        5.3
0130082 810527 0955    5.00  7.21      -99     9.00   11.19       -9.9
0130082 810527 0955   10.00  7.23      -99     7.70   11.17       -9.9
0130082 810527 0955   15.00  7.25      -99     6.70   11.20       -9.9
0130082 810527 0955   20.00  7.26      -99     6.70   11.32       -9.9
0130082 810527 0955   25.00  7.25      -99     6.50   11.34       -9.9
0130082 810527 0955   30.00  7.28      -99     5.70   11.18       -9.9
0130082 810527 0955   35.00  7.49      -99     5.60   11.22       -9.9

** 810608
0130082 810608 0915    0.00  6.86      -99    11.60   10.10        6.3
0130082 810608 0915    5.00  6.92      -99    10.20   10.16       -9.9
0130082 810608 0915   10.00  6.96      -99     9.30   10.03       -9.9
0130082 810608 0915   15.00  7.00      -99     8.00    9.70       -9.9
0130082 810608 0915   20.00  7.06      -99     7.20    9.87       -9.9
0130082 810608 0915   25.00  7.13      -99     6.60    9.80       -9.9
0130082 810608 0915   30.00  7.17      -99     6.30   10.00       -9.9
0130082 810608 0915   35.00  7.21      -99     6.10   10.46       -9.9
0130082 810608 0915   40.00  7.25      -99     5.80   10.23       -9.9

** 810624
0130082 810624 1010    0.00  7.12      -99    12.60   10.22        8.7
0130082 810624 1010    5.00  7.17      -99    11.50   10.01       -9.9
0130082 810624 1010   10.00  7.16      -99    10.70   10.04       -9.9
0130082 810624 1010   15.00  7.12      -99     9.70   10.01       -9.9
0130082 810624 1010   20.00  7.15      -99     7.40   10.04       -9.9
0130082 810624 1010   25.00  7.21      -99     6.60   10.22       -9.9
0130082 810624 1010   30.00  7.26      -99     6.10   10.23       -9.9

** 810721
0130082 810721 1130    0.00  6.82      -99    19.30    9.02       12.5
0130082 810721 1130    5.00  6.97      -99    17.80    8.96       -9.9
0130082 810721 1130   10.00  7.01      -99    16.20    8.91       -9.9
0130082 810721 1130   12.50  6.98      -99    15.20    9.15       -9.9
0130082 810721 1130   15.00  6.98      -99    14.20    9.03       -9.9
0130082 810721 1130   17.50  7.09      -99    12.10    9.78       -9.9
0130082 810721 1130   20.00  7.11      -99    10.40    9.79       -9.9
0130082 810721 1130   22.50  7.17      -99     8.50   10.16       -9.9
0130082 810721 1130   25.00  7.17      -99     7.80   10.26       -9.9

** 810812
0130082 810812 0000    0.00  7.19      -99    24.40    8.11       12.0
0130082 810812 0000    5.00  7.17      -99    22.80    8.27       -9.9
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                         BUTTLE LAKE WATER QUALITY PROFILES
                                FOR SITE 0130082

SITE     DATE   TIME    DEPTH      PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
         y m d              m            uS/cm    deg C    mg/l          m
------- ------ ------ ----- ----- -------- -------- ------- ----------


0130082 810812 0000   10.00  7.11      -99    19.30    8.24       -9.9
0130082 810812 0000   15.00  7.50      -99    10.20   10.25       -9.9
0130082 810812 0000   20.00  7.49      -99     9.10   10.27       -9.9
0130082 810812 0000   25.00  7.52      -99     7.50   10.27       -9.9
0130082 810812 0000   30.00  7.56      -99     6.70   10.27       -9.9
0130082 810812 0000   35.00  7.64      -99     6.30   10.31       -9.9
0130082 810812 0000   40.00  7.66      -99     6.10   10.46       -9.9
0130082 810812 0000   45.00  7.66      -99     6.00   10.54       -9.9
0130082 810812 0000   50.00  7.69      -99     5.90   10.58       -9.9

** 810820
0130082 810820 0945    0.00  6.87      -99    21.80    8.03       10.5
0130082 810820 0945    5.00  7.00      -99    21.70    7.88       -9.9
0130082 810820 0945    7.50  7.10      -99    17.50    8.77       -9.9
0130082 810820 0945   10.00  7.13      -99    14.90    8.95       -9.9
0130082 810820 0945   15.00  7.18      -99    12.10    8.92       -9.9
0130082 810820 0945   20.00  7.24      -99     8.80    9.55       -9.9
0130082 810820 0945   25.00  7.29      -99     7.50    9.74       -9.9
0130082 810820 0945   30.00  7.40      -99     6.90    9.97       -9.9
0130082 810820 0945   35.00  7.60      -99     6.80    9.91       -9.9
0130082 810820 0945   40.00  7.61      -99     6.40   10.04       -9.9

** 810922
0130082 810922 1200    0.00  7.34      -99    16.60    8.70        6.5
0130082 810922 1200    5.00  7.25      -99    15.80    8.50       -9.9
0130082 810922 1200   10.00  7.18      -99    14.00   -9.99       -9.9
0130082 810922 1200   15.00  7.24      -99    11.20   10.10       -9.9
0130082 810922 1200   20.00  7.38      -99     8.00    9.90       -9.9
0130082 810922 1200   25.00  7.34      -99     7.90    9.50       -9.9
0130082 810922 1200   30.00  8.02      -99     6.90    9.50       -9.9
0130082 810922 1200   35.00  7.94      -99     6.80    9.80       -9.9

** 811021
0130082 811021 0000    0.00 -9.99      -99   -99.99   -9.99        7.0
0130082 811021 0000    1.00  7.10      -99    11.60   10.15       -9.9
0130082 811021 0000    2.00  7.11      -99    11.60   10.06       -9.9
0130082 811021 0000    3.00  7.12      -99    11.70    9.98       -9.9
0130082 811021 0000    4.00  7.12      -99    11.70    9.95       -9.9
0130082 811021 0000    5.00  7.11      -99    11.70    9.93       -9.9
0130082 811021 0000    6.00  7.10      -99    11.70    9.93       -9.9
0130082 811021 0000    8.00  7.11      -99    11.70    9.94       -9.9
0130082 811021 0000   10.00  7.11      -99    11.70    9.87       -9.9
0130082 811021 0000   12.00  7.07      -99    11.30    9.75       -9.9
0130082 811021 0000   14.00  7.02      -99    10.90    9.70       -9.9
0130082 811021 0000   16.00  6.99      -99    10.70    9.80       -9.9
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                       BUTTLE LAKE WATER QUALITY PROFILES
                              FOR SITE 0130082

 SITE    DATE   TIME   DEPTH    PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
         y m d                m             uS/cm    deg C   mg/l          m
 ------- ------ ------ ----- ----- -------- -------- ------- ----------


 0130082 811021 0000  18.00  6.99      -99    10.60   10.02       -9.9
 0130082 811021 0000  20.00  6.99      -99    10.20   10.05       -9.9
 0130082 811021 0000  22.00  6.98      -99     9.09    9.83       -9.9
 0130082 811021 0000  24.00  7.08      -99     8.00   10.03       -9.9
 0130082 811021 0000  26.00  7.09      -99     7.50   10.09       -9.9
 0130082 811021 0000  28.00  7.12      -99     7.40   10.13       -9.9
 0130082 811021 0000  30.00  7.16      -99     7.20    9.97       -9.9
 0130082 811021 0000  35.00  7.21      -99     6.90    9.77       -9.9
 0130082 811021 0000  40.00  7.26      -99     6.70    9.83       -9.9
 0130082 811021 0000  45.00  7.26      -99     6.60    9.82       -9.9
 0130082 811021 0000  50.00  7.33      -99     6.60    9.44       -9.9

**  811028
 0130082 811028 1200   0.00  3.00      -99   -99.99   -9.99       -9.9
 0130082 811028 1200   5.00  3.00      -99   -99.99   -9.99       -9.9
 0130082 811028 1200  10.00  3.00      -99   -99.99   -9.99       -9.9
 0130082 811028 1200  15.00  3.00      -99   -99.99   -9.99       -9.9

**  811118
 0130082 811118 0000   0.00 -9.99      -99   -99.99   -9.99        1.8

**  811208
 0130082 811208 1420   0.00  7.40      -99     6.70   11.10        2.3
 0130082 811208 1420   2.50  7.30      -99     6.70   10.70       -9.9
 0130082 811208 1420   5.00  7.30      -99     6.70   10.60       -9.9
 0130082 811208 1420   7.50  7.30      -99     6.70   10.70       -9.9
 0130082 811208 1420   9.00  7.50      -99     6.70   10.00       -9.9

**  820119
 0130082 820119 1200   0.00  7.92       41     4.50    8.60        2.0
 0130082 820119 1200   5.00  7.50       39     4.50    8.40       -9.9
 0130082 820119 1200  10.00  7.42       50     4.50    8.60       -9.9
 0130082 820119 1200  15.00  6.75       51     4.50    8.60       -9.9
 0130082 820119 1200  20.00  5.45       68     5.10    8.60       -9.9

**  820215
 0130082 820215 1230   0.00 -9.99      -99     3.90   11.80        3.0
 0130082 820215 1230   5.00 -9.99      -99     3.90   11.30       -9.9
 0130082 820215 1230  10.00 -9.99      -99     3.90   11.30       -9.9
 0130082 820215 1230  15.00 -9.99      -99     3.90   11.20       -9.9
 0130082 820215 1230  20.00 -9.99      -99     3.90   11.00       -9.9
 0130082 820215 1230  25.00 -9.99      -99     3.90   10.90       -9.9
 0130082 820215 1230  30.00 -9.99      -99     3.90   10.90       -9.9
 0130082 820215 1230  35.00 -9.99      -99     3.90   10.90       -9.9
 0130082 820215 1230  40.00 -9.99      -99     3.90   10.80       -9.9
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BUTTLE LAKE WATER QUALITY PROFILES
FOR SITE 0130082

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SITE    DATE   TIME   DEPTH     PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
        y m d             m          uS/cm    deg C    mg/l           m
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0130082 820215 1230   45.00 -9.99      -99     3.90   10.70       -9.9
0130082 820215 1230   50.00 -9.99      -99     3.90   10.70       -9.9

**  820323
0130082 820323 1515    0.00  6.50      131     8.50   10.40        4.5
0130082 820323 1515    5.00  6.20      140     5.50   10.20       -9.9
0130082 820323 1515   10.00  5.80      130     5.00   10.20       -9.9
0130082 820323 1515   15.00  5.70      155     5.00   10.20       -9.9
0130082 820323 1515   20.00  5.60      142     4.50   10.20       -9.9

**  820420
0130082 820420 1345    0.00  6.45       59     7.50   10.20        4.0
0130082 820420 1345    5.00  6.00       71     6.50   10.00       -9.9
0130082 820420 1345   10.00  5.65       75     5.75    9.90       -9.9
0130082 820420 1345   15.00  5.55       80     5.50    9.95       -9.9
0130082 820420 1345   20.00  5.50       85     5.50    9.90       -9.9

**  820519
0130082 820519 1230    0.00  7.35       62     8.00   14.80       -9.9
0130082 820519 1230    5.00  6.95       65     7.50   14.90       -9.9
0130082 820519 1230   10.00 12.00       67     7.50   14.60       -9.9
0130082 820519 1230   15.00 12.00       70     6.50   14.60       -9.9
0130082 820519 1230   20.00 12.00       48     6.00   14.20       -9.9

**  820615
0130082 820615 1050    0.00  7.60       60    16.20   10.80        5.0
0130082 820615 1050    5.00  7.60       60    14.50   11.00       -9.9
0130082 820615 1050   10.00  7.40       55    12.50   11.30       -9.9
0130082 820615 1050   15.00  7.40       51    11.00   11.40       -9.9
0130082 820615 1050   20.00  7.40       54     9.50   12.10       -9.9

**  820720
0130082 820720 1450    0.00  7.45      -99    16.10    8.28        6.5
0130082 820720 1450    5.00  7.46      -99    16.00    8.49       -9.9
0130082 820720 1450   10.00  7.45      -99    14.90    8.46       -9.9
0130082 820720 1450   15.00  7.38      -99    13.20    8.61       -9.9
0130082 820720 1450   20.00  7.33      -99    10.20    8.77       -9.9
0130082 820720 1450   25.00  7.22      -99     8.20    9.62       -9.9
0130082 820720 1450   30.00  7.30      -99     6.80    9.47       -9.9
0130082 820720 1450   35.00  7.46      -99     6.00    9.50       -9.9
0130082 820720 1450   40.00  7.47      -99     5.70    9.62       -9.9
0130082 820720 1450   45.00  7.44      -99     5.60    9.61       -9.9
0130082 820720 1450   50.00  7.41      -99     5.30    9.60       -9.9
0130082 820720 1450   55.00  7.36      -99     5.30    9.60       -9.9
0130082 820720 1450   60.00  7.31      -99     5.00    9.70       -9.9
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                   BUTTLE LAKE WATER QUALITY PROFILES
                           FOR SITE 0130082

SITE    DATE   TIME   DEPTH     PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
        y m d             m          uS/cm    deg C    mg/l           m
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0130082 820720 1450   65.00  7.26      -99     4.90    9.44        -9.9

**  820929
0130082 820929 1340    0.00 -9.99      -99    16.20    8.40        13.5
0130082 820929 1340    5.00 -9.99      -99    16.00    8.90        -9.9
0130082 820929 1340   10.00 -9.99      -99    16.00    8.80        -9.9
0130082 820929 1340   15.00 -9.99      -99    15.50    9.00        -9.9
0130082 820929 1340   20.00 -9.99      -99     9.00    9.80        -9.9
0130082 820929 1340   25.00 -9.99      -99     7.50    9.90        -9.9
0130082 820929 1340   30.00 -9.99      -99     7.50   10.00        -9.9

**  840214
0130082 840214 1200    0.00  6.80       80     3.70   13.10         6.0
0130082 840214 1200    5.00  6.91       79     3.60   12.87        -9.9
0130082 840214 1200   10.00  6.90       79     3.60   12.69        -9.9
0130082 840214 1200   15.00  6.94       80     3.60   12.63        -9.9
0130082 840214 1200   20.00  6.93       80     3.70   12.75        -9.9
0130082 840214 1200   25.00  6.94       81     3.70   12.35        -9.9
0130082 840214 1200   30.00  6.94       82     3.70   12.22        -9.9
0130082 840214 1200   35.00  6.94       82     3.70   12.17        -9.9
0130082 840214 1200   40.00  6.96       82     3.70   12.12        -9.9
0130082 840214 1200   45.00  6.96       82     3.70   12.05        -9.9
0130082 840214 1200   50.00  6.95       83     3.70   12.02        -9.9

**  840501
0130082 840501 1240    0.00 -9.99      -99   -99.99   -9.99         6.0

**  840619
0130082 840619 1230    0.00 -9.99      -99   -99.99   -9.99         5.0

**  840726
0130082 840726 1422    0.00 -9.99      -99   -99.99   -9.99         7.0

**  840822
0130082 840822 1330    0.00 -9.99      -99   -99.99   -9.99         6.5

**  841002
0130082 841002 1400    0.00 -9.99      -99   -99.99   -9.99         5.0

**  841211
0130082 841211 1525    0.00 -9.99      -99   -99.99   -9.99         5.0

**  850209
0130082 850209 1130    0.00 -9999      -99   -99.99   -9.99         6.0
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                     BUTTLE LAKE WATER QUALITY PROFILES
                             FOR SITE 0130082

SITE    DATE   TIME   DEPTH    PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
        y m d             m          uS/cm    deg C    mg/l          m
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** 850430
0130082 850430 1410    0.00 -9.99      -99   -99.99   -9.99        5.5

** 850604
0130082 850604 1430    0.00 -9.99      -99   -99.99   -9.99        4.0

** 850709
0130082 850709 1400    0.00 -9.99      -99   -99.99   -9.99        6.0

** 850813
0130082 850813 1030    0.00 -9.99      -99   -99.99   -9.99        7.5

** 850917
0130082 850917 1400    0.00 -9.99      -99    16.61   10.10        7.5
0130082 850917 1400    5.00  7.32      -99    16.11    9.90       -9.9
0130082 850917 1400   10.00  7.32      -99    15.70    9.90       -9.9
0130082 850917 1400   15.00  7.16      -99    12.00   10.80       -9.9
0130082 850917 1400   20.00  7.12      -99     8.20   11.60       -9.9
0130082 850917 1400   25.00  7.05      -99     7.30   11.70       -9.9
0130082 850917 1400   30.00  7.02      -99     7.00   11.70       -9.9
0130082 850917 1400   35.00  6.99      -99     6.50   11.70       -9.9
0130082 850917 1400   40.00  6.97      -99     6.20   11.60       -9.9
0130082 850917 1400   45.00  6.97      -99     6.00   11.70       -9.9
0130082 850917 1400   50.00  6.96      -99     5.80   11.60       -9.9
0130082 850917 1400   55.00  6.96      -99     5.60   11.60       -9.9

** 851022
0130082 851022 1240    0.00 -9.99      -99   -99.99   -9.99        8.0

** 851212
0130082 851212 1230    0.00  7.28       77     4.53   11.42        8.0
0130082 851212 1230    5.00  7.19       78     4.55   11.26       -9.9
0130082 851212 1230   10.00  7.13       77     4.55   11.26       -9.9
0130082 851212 1230   15.00  7.13       78     4.55   11.19       -9.9
0130082 851212 1230   20.00  7.12       78     4.55   11.19       -9.9
0130082 851212 1230   25.00  7.12       78     4.52   11.15       -9.9
0130082 851212 1230   30.00  7.14       78     4.52   11.08       -9.9
0130082 851212 1230   30.00  7.14       78     4.52   11.08       -9.9
0130082 851212 1230   35.00  7.14       79     4.52   11.09       -9.9
0130082 851212 1230   40.00  7.15       80     4.48   11.11       -9.9
9130082 851212 1230   45.00  7.14       80     4.42   11.08       -9.9
0130082 851212 1230   50.00  7.15       82     4.40   11.04       -9.9

** 860211
0130082 860211 1010    0.00  7.52       69     3.13    9.38        5.0
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                BUTTLE LAKE WATER QUALITY PROFILES
                        FOR SITE 0130082

SITE    DATE   TIME   DEPTH      PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
        y m d             m            uS/cm    deg C    mg/l          m
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0130082 860211 1010    5.00  7.41       68     3.36    9.51       -9.9
0130082 860211 1010   10.00  7.37       68     3.43    8.94       -9.9
0130082 860211 1010   15.00  7.31       77     3.56    8.71       -9.9
0130082 860211 1010   20.00  7.28       86     3.72    8.31       -9.9
0130082 860211 1010   25.00  7.27       87     3.51    8.36       -9.9
0130082 860211 1010   30.00  7.26       88     3.51    8.42       -9.9
0130082 860211 1010   35.00  7.26       89     3.49    8.45       -9.9
0130082 860211 1010   40.00  7.25       90     3.49    8.43       -9.9
0130082 860211 1010   45.00  7.26       91     3.34    8.57       -9.9
0130082 860211 1010   50.00  7.25       93     3.33    8.63       -9.9
0130082 860211 1010   55.00  7.24       93     3.32    8.63       -9.9
0130082 860211 1010   60.00  7.24       95     3.32    8.63       -9.9

** 860415
0130082 860415 1120    0.00  7.23       72     6.52   12.48        7.0
0130082 860415 1120    5.00  7.18       74     6.22   12.47       -9.9
0130082 860415 1120   10.00  7.16       76     5.93   12.44       -9.9
0130082 860415 1120   15.00  7.15       76     5.49   12.49       -9.9
0130082 860415 1120   20.00  7.13       80     4.68   12.48       -9.9
0130082 860415 1120   25.00  7.10       80     4.59   12.43       -9.9
0130082 860415 1120   30.00  7.08       84     4.37   12.32       -9.9
0130082 860415 1120   35.00  7.07       85     4.21   12.24       -9.9
0130082 860415 1120   40.00  7.06       86     4.20   12.18       -9.9
0130082 860415 1120   45.00  7.05       86     4.21   12.11       -9.9
0130082 860415 1120   50.00  7.04       85     4.13   12.11       -9.9
0130082 860415 1120   55.00  7.04       86     4.05   12.10       -9.9
0130082 860415 1120   60.00  7.04       85     3.92   12.13       -9.9
0130082 860415 1120   65.00  7.03       86     3.81   11.99       -9.9
0130082 860415 1120   70.00  7.02       85     3.67   11.97       -9.9

** 860512
0130082 860512 1400    0.00  7.28       76     7.86   12.09        6.0
0130082 860512 1400    5.00  7.27       76     7.85   12.09       -9.9
0130082 860512 1400   10.00  7.25       76     7.57   12.11       -9.9
0130082 860512 1400   15.00  7.25       75     6.43   12.17       -9.9
0130082 860512 1400   20.00  7.21       74     5.97   12.18       -9.9
0130082 860512 1400   25.00  7.19       74     5.07   12.14       -9.9
0130082 860512 1400   30.00  7.14       79     4.89   12.12       -9.9
0130082 860512 1400   35.00  7.11       81     4.76   12.09       -9.9
0130082 860512 1400   40.00  7.08       81     4.67   12.03       -9.9
0130082 860512 1400   45.00  7.07       83     4.61   12.00       -9.9
0130082 860512 1400   50.00  7.05       83     4.55   11.97       -9.9

** 860610
0130082 860610 1220    0.00  6.95       65    13.96   11.13        6.0
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BUTTLE LAKE WATER QUALITY PROFILES
FOR SITE 0130082

SITE	DATE y m d	TIME	DEPTH m	PH	SPF COND uS/cm	TEMP H2O deg C	DISS O2 mg/l	EXTN DEPTH m
0130082	860610	1220	5.00	7.05	64	13.17	11.21	-9.9
0130082	860610	1220	10.00	7.07	63	10.74	11.30	-9.9
0130082	860610	1220	15.00	7.05	64	8.66	11.62	-9.9
0130082	860610	1220	20.00	7.03	63	7.36	12.05	-9.9
0130082	860610	1220	25.00	7.01	63	6.56	12.08	-9.9
0130082	860610	1220	30.00	7.00	65	6.14	11.98	-9.9
0130082	860610	1220	35.00	6.99	72	5.70	11.89	-9.9
0130082	860610	1220	40.00	6.98	75	5.41	11.84	-9.9
0130082	860610	1220	45.00	6.97	77	5.28	11.77	-9.9
0130082	860610	1220	50.00	6.96	78	5.15	11.71	-9.9
0130082	860610	1220	55.00	6.96	82	4.86	11.67	-9.9
0130082	860610	1220	60.00	6.97	83	4.72	11.65	-9.9
** 860708								
0130082	860708	1400	0.00	7.30	62	16.02	10.21	8.0
0130082	860708	1400	5.00	7.31	62	14.65	10.09	-9.9
0130082	860708	1400	10.00	7.28	62	12.70	10.54	-9.9
0130082	860708	1400	15.00	7.28	61	10.77	10.36	-9.9
0130082	860708	1400	20.00	7.14	65	7.75	11.49	-9.9
0130082	860708	1400	25.00	7.11	69	6.65	11.60	-9.9
0130082	860708	1400	30.00	7.09	69	6.40	11.65	-9.9
0130082	860708	1400	35.00	7.06	70	6.10	11.64	-9.9
0130082	860708	1400	40.00	7.03	75	5.69	11.58	-9.9
0130082	860708	1400	45.00	7.01	75	5.40	11.46	-9.9
0130082	860708	1400	50.00	7.01	79	5.18	11.56	-9.9
** 860812								
0130082	860812	1100	0.00	7.26	64	21.34	9.04	14.0
0130082	860812	1100	5.00	7.28	64	20.81	9.08	-9.9
0130082	860812	1100	10.00	7.17	69	18.19	9.15	-9.9
0130082	860812	1100	15.00	7.08	70	12.92	10.25	-9.9
0130082	860812	1100	20.00	7.04	66	7.88	11.07	-9.9
0130082	860812	1100	25.00	6.97	68	7.05	11.32	-9.9
0130082	860812	1100	30.00	6.92	69	6.71	11.33	-9.9
0130082	860812	1100	35.00	6.99	70	6.43	11.34	-9.9
0130082	860812	1100	40.00	6.85	75	5.93	11.33	-9.9
0130082	860812	1100	45.00	6.83	76	5.68	11.26	-9.9
0130082	860812	1100	50.00	6.81	78	5.37	11.22	-9.9
** 870204								
0130082	870204	1230	0.00	7.19	70	3.69	14.20	-9.9
0130082	870204	1230	5.00	7.14	70	3.66	13.60	-9.9
0130082	870204	1230	10.00	7.12	70	3.64	13.54	-9.9
0130082	870204	1230	15.00	7.10	70	3.62	13.46	-9.9
0130082	870204	1230	20.00	7.09	71	3.64	13.45	-9.9

BUTTLE LAKE WATER QUALITY PROFILES
FOR SITE 0130082

SITE	DATE y m d	TIME	DEPTH m	PH	SPF COND uS/cm	TEMP H2O deg C	DISS O2 mg/l	EXTN DEPTH m
0130082	870204	1230	25.00	7.05	75	3.78	13.40	-9.9
0130082	870204	1230	30.00	7.02	76	3.80	13.30	-9.9
0130082	870204	1230	35.00	7.01	80	3.76	13.33	-9.9
0130082	870204	1230	40.00	7.01	81	3.69	13.34	-9.9
0130082	870204	1230	45.00	7.00	81	3.70	13.32	-9.9
0130082	870204	1230	50.00	6.99	82	3.67	13.26	-9.9
** 870414								
0130082	870414	1130	0.00	7.20	75	5.38	12.39	6.0
0130082	870414	1130	5.00	7.08	75	5.29	12.32	-9.9
0130082	870414	1130	10.00	7.07	75	5.07	12.37	-9.9
0130082	870414	1130	15.00	7.04	75	4.98	12.35	-9.9
0130082	870414	1130	20.00	7.02	75	4.86	12.32	-9.9
0130082	870414	1130	25.00	7.03	75	4.48	12.32	-9.9
0130082	870414	1130	30.00	6.96	82	4.35	12.32	-9.9
0130082	870414	1130	35.00	6.94	83	4.27	12.31	-9.9
0130082	870414	1130	40.00	6.91	84	4.23	12.34	-9.9
0130082	870414	1130	45.00	6.90	84	4.18	12.30	-9.9
0130082	870414	1130	50.00	6.89	983	4.05	12.27	-9.9
** 870909								
0130082	870909	1355	0.00	7.38	64	20.67	9.61	13.5
0130082	870909	1355	5.00	7.42	63	19.34	9.85	-9.9
0130082	870909	1355	10.00	7.30	70	18.22	10.01	-9.9
0130082	870909	1355	15.00	7.11	64	11.61	11.24	-9.9
0130082	870909	1355	20.00	6.98	65	8.49	11.92	-9.9
0130082	870909	1355	25.00	6.93	66	7.48	12.04	-9.9
0130082	870909	1355	30.00	6.89	69	7.03	12.11	-9.9
0130082	870909	1355	35.00	6.81	75	6.26	11.99	-9.9
0130082	870909	1355	40.00	6.76	76	5.88	11.99	-9.9
0130082	870909	1355	45.00	6.72	76	5.68	12.07	-9.9
0130082	870909	1355	50.00	6.69	78	5.53	12.05	-9.9
** 880510								
0130082	880510	1030	0.00	7.42	71	9.27	10.54	-9.9
0130082	880510	1030	5.00	7.37	70	8.08	11.06	-9.9
0130082	880510	1030	10.00	7.36	71	7.68	11.23	-9.9
0130082	880510	1030	15.00	7.33	71	6.97	11.45	-9.9
0130082	880510	1030	20.00	7.31	72	6.51	11.69	-9.9
0130082	880510	1030	25.00	7.28	73	6.08	11.86	-9.9
0130082	880510	1030	30.00	7.26	75	5.79	11.99	-9.9
0130082	880510	1030	35.00	7.24	75	5.63	12.08	-9.9
0130082	880510	1030	40.00	7.23	73	5.38	12.17	-9.9
0130082	880510	1030	45.00	-9.99	-99	5.17	-9.99	-9.9

BUTTLE LAKE WATER QUALITY PROFILES
FOR SITE 0130082

SITE	DATE y m d	TIME	DEPTH m	PH	SPF COND uS/cm	TEMP H2O deg C	DISS O2 mg/l	EXTN DEPTH m
** 880614								
0130082	880614	1000	0.00	7.30	66	13.63	8.60	-9.9
0130082	880614	1000	5.00	7.31	68	11.75	9.43	-9.9
0130082	880614	1000	7.50	7.28	67	10.70	9.80	-9.9
0130082	880614	1000	10.00	7.25	67	10.40	9.92	-9.9
0130082	880614	1000	15.00	7.20	65	9.02	10.37	-9.9
0130082	880614	1000	20.00	7.13	68	7.47	10.92	-9.9
0130082	880614	1000	25.00	7.06	71	6.61	11.25	-9.9
0130082	880614	1000	30.00	7.02	74	6.16	11.39	-9.9
0130082	880614	1000	35.00	6.97	80	5.61	11.67	-9.9
0130082	880614	1000	40.00	6.92	85	5.22	11.77	-9.9
0130082	880614	1000	45.00	6.91	87	5.15	11.86	-9.9
0130082	880614	1000	50.00	6.89	90	4.99	12.00	-9.9
** 880706								
0130082	880706	1030	0.00	7.32	65	12.59	8.72	-9.9
0130082	880706	1030	5.00	7.31	64	12.16	8.86	-9.9
0130082	880706	1030	10.00	7.28	64	11.42	9.33	-9.9
0130082	880706	1030	15.00	7.23	63	10.04	9.68	-9.9
0130082	880706	1030	20.00	7.14	67	8.29	10.12	-9.9
0130082	880706	1030	25.00	7.06	73	6.84	11.03	-9.9
0130082	880706	1030	30.00	7.00	79	6.07	11.28	-9.9
0130082	880706	1030	35.00	6.96	82	5.70	11.19	-9.9
0130082	880706	1030	40.00	6.93	82	5.58	10.99	-9.9
** 880913								
0130082	880913	1255	0.00	7.52	64	17.73	9.98	18.5
0130082	880913	1255	5.00	7.49	65	17.25	10.77	-9.9
0130082	880913	1255	10.00	7.46	65	17.02	11.05	-9.9
0130082	880913	1255	15.00	7.34	67	11.99	12.77	-9.9
0130082	880913	1255	20.00	7.28	69	8.79	13.51	-9.9
0130082	880913	1255	25.00	7.14	71	7.59	13.40	-9.9
0130082	880913	1255	30.00	7.09	74	7.18	13.82	-9.9
0130082	880913	1255	35.00	7.04	79	6.50	14.14	-9.9
0130082	880913	1255	40.00	7.00	81	6.11	13.57	-9.9
0130082	880913	1255	45.00	6.96	82	5.95	13.98	-9.9
0130082	880913	1255	50.00	6.93	85	5.72	13.96	-9.9
** 881108								
0130082	881108	1115	0.00	6.96	71	9.43	9.81	7.0
0130082	881108	1115	5.00	6.96	71	9.38	10.64	-9.9
0130082	881108	1115	10.00	6.93	68	8.86	10.78	-9.9
0130082	881108	1115	15.00	6.89	71	8.31	10.87	-9.9
0130082	881108	1115	20.00	6.87	66	7.97	12.11	-9.9
0130082	881108	1115	25.00	6.84	66	7.82	12.08	-9.9

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                    BUTTLE LAKE WATER QUALITY PROFILES
                           FOR SITE 0130082

SITE     DATE   TIME    DEPTH     PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
         y m d              m          uS/cm    deg C    mg/l           m
------- ------ ------ ----- ----- -------- -------- ------- ----------


0130082 881108 1115   30.00  6.81       73     7.22   11.10       -9.9
0130082 881108 1115   35.00  6.77       77     6.83   11.01       -9.9
0130082 881108 1115   40.00  6.73       83     6.18   10.26       -9.9
0130082 881108 1115   45.00  6.71       83     5.94   10.35       -9.9
0130082 881108 1115   50.00  6.69       86     5.61   10.34       -9.9
0130082 881108 1115   55.00  6.67       87     5.47   10.36       -9.9

**  890118
0130082 890118 1154    0.00  7.20       85     4.59   11.62       11.0
0130082 890118 1154    5.00  7.13       84     4.59   11.57       -9.9
0130082 890118 1154   10.00  7.08       84     4.57   11.51       -9.9
0130082 890118 1154   15.00  7.06       84     4.57   11.51       -9.9
0130082 890118 1154   20.00  7.03       84     4.57   11.51       -9.9
0130082 890118 1154   25.00  7.02       82     4.57   11.73       -9.9
0130082 890118 1154   30.00  7.01       83     4.55   12.98       -9.9
0130082 890118 1154   35.00  6.99       82     4.55   12.22       -9.9
0130082 890118 1154   40.00  6.98       82     4.51   11.84       -9.9
0130082 890118 1154   45.00  6.97       83     4.49   11.71       -9.9
0130082 890118 1154   50.00  6.97       83     4.49   11.64       -9.9

**  890511
0130082 890511 0915    0.00  7.22       73     7.61    9.41        5.5
0130082 890511 0915    5.00  7.27       75     7.04    9.61       -9.9
0130082 890511 0915   10.00  7.30       73     6.76    9.73       -9.9
0130082 890511 0915   15.00  7.31       75     6.39    9.83       -9.9
0130082 890511 0915   20.00  7.29       78     5.77   10.02       -9.9
0130082 890511 0915   25.00  7.29       82     5.46   10.09       -9.9
0130082 890511 0915   30.00  7.26       89     5.00   10.10       -9.9
0130082 890511 0915   35.00  7.25       89     4.89   10.10       -9.9
0130082 890511 0915   40.00  7.23       93     4.55   10.10       -9.9
0130082 890511 0915   45.00  7.19       93     4.45   10.09       -9.9
0130082 890511 0915   50.00  7.19       95     4.29   10.04       -9.9

**  890613
0130082 890613 1150    0.00  7.51       71    15.53   10.04        7.0
0130082 890613 1150    5.00  7.48       67    14.82   10.38       -9.9
0130082 890613 1150   10.00  7.53       63    12.13   11.19       -9.9
0130082 890613 1150   15.00  7.52       71     9.50   11.59       -9.9
0130082 890613 1150   20.00  7.47       75     7.34   12.25       -9.9
0130082 890613 1150   25.00  7.42       79     6.55   12.50       -9.9
0130082 890613 1150   30.00  7.36       85     5.77   12.01       -9.9
0130082 890613 1150   35.00  7.33       89     5.36   12.14       -9.9
0130082 890613 1150   40.00  7.30       88     5.21   12.17       -9.9
0130082 890613 1150   45.00  7.26       91     4.97   11.97       -9.9
0130082 890613 1150   50.00  7.23       92     4.87   11.98       -9.9
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                          BUTTLE LAKE WATER QUALITY PROFILES
                                 FOR SITE 0130082

SITE     DATE   TIME    DEPTH     PH SPF COND TEMP H2O DISS O2 EXTN DEPTH
         y m d              m           uS/cm    deg C    mg/l          m
------- ------ ------ ----- ----- -------- -------- ------- ----------


0130082 890613 1150   55.00  7.21       93     4.72   11.88        -9.9
0130082 890613 1150   60.00  7.19       94     4.65   11.86        -9.9

** 890822
0130082 890822 1000    0.00  7.30       71    18.50    9.40        12.0
0130082 890822 1000    5.00  7.33       68    18.48    9.45        -9.9
0130082 890822 1000   10.00  7.34       81    16.02    9.60        -9.9
0130082 890822 1000   15.00  7.42       71    12.56   10.78        -9.9
0130082 890822 1000   20.00  7.44       75     8.31   11.32        -9.9
0130082 890822 1000   25.00  7.39       77     7.11   11.57        -9.9
0130082 890822 1000   30.00  7.38       78     6.70   11.58        -9.9
0130082 890822 1000   35.00  7.34       86     6.37   11.27        -9.9
0130082 890822 1000   40.00  7.32       86     5.63   11.17        -9.9
0130082 890822 1000   45.00  7.32       86     5.63   11.17        -9.9
0130082 890822 1000   50.00  7.29       88     5.31   11.12        -9.9

** 891024
0130082 891024 1000    0.00  7.57       75    12.30   10.47        11.0
0130082 891024 1000    5.00  7.57       75    12.30   10.78        -9.9
0130082 891024 1000   10.00  7.59       73    11.17   10.55        -9.9
0130082 891024 1000   15.00  7.57       69    10.31   10.80        -9.9
0130082 891024 1000   20.00  7.50       71     9.56   10.88        -9.9
0130082 891024 1000   25.00  7.47       79     7.14   10.99        -9.9
0130082 891024 1000   30.00  7.43       80     6.56   10.99        -9.9
0130082 891024 1000   35.00  7.39       85     6.08   10.80        -9.9
0130082 891024 1000   40.00  7.39       87     5.83   10.69        -9.9
0130082 891024 1000   45.00  7.31       89     5.58   10.58        -9.9
0130082 891024 1000   50.00  7.30       89     5.39   10.51        -9.9

** 891212
0130082 891212 1020    0.00 -9.99      -99     6.28   10.95        -9.9
0130082 891212 1020    5.00 -9.99      -99     6.28   10.95        -9.9
0130082 891212 1020   10.00 -9.99      -99     6.28   10.95        -9.9
0130082 891212 1020   15.00 -9.99      -99     6.19   11.11        -9.9
0130082 891212 1020   20.00 -9.99      -99     6.09   11.08        -9.9
0130082 891212 1020   25.00 -9.99      -99     6.06   11.00        -9.9
0130082 891212 1020   30.00 -9.99      -99     6.02   11.03        -9.9
0130082 891212 1020   35.00 -9.99      -99     6.00   10.99        -9.9
0130082 891212 1020   40.00 -9.99      -99     5.96   10.97        -9.9
0130082 891212 1020   45.00 -9.99      -99     5.90   10.86        -9.9
0130082 891212 1020   50.00 -9.99      -99     5.63   10.43        -9.9
0130082 891212 1020   55.00 -9.99      -99     5.34    9.93        -9.9
0130082 891212 1020   60.00 -9.99      -99     5.28    9.71        -9.9
```

Climate Data for Myra Creek Weather Station

(Negative 9 values indicate missing data)

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                      WEATHER DATA
                       MYRA CREEK

YEAR MONTH   RAIN    SNOW TOTAL PCPN MAX T MIN T
               mm      cm         mm deg C deg C
---- ----- ------ ------ ---------- ----- -----


** 1968
1968     1  587.0  189.0      776.0 -99.9 -99.9
1968     2  304.0   15.0      319.0 -99.9 -99.9
1968     3  364.0    0.0      364.0 -99.9 -99.9
1968     4  157.0    6.0      163.0 -99.9 -99.9
1968     5   64.0    0.0       64.0 -99.9 -99.9
1968     6  114.0    0.0      114.0 -99.9 -99.9
1968     7   46.0    0.0       46.0 -99.9 -99.9
1968     8   89.0    0.0       89.0 -99.9 -99.9
1968     9  154.0    0.0      154.0 -99.9 -99.9
1968    10  777.0    0.0      777.0 -99.9 -99.9
1968    11  557.0    5.0      562.0 -99.9 -99.9
1968    12   89.0   73.0      162.0 -99.9 -99.9

** 1969
1969     1  240.0  109.0      349.0 -99.9 -99.9
1969     2  257.0   59.0      316.0 -99.9 -99.9
1969     3  258.0   15.0      273.0 -99.9 -99.9
1969     4  389.0   15.0      404.0 -99.9 -99.9
1969     5  147.0    0.0      147.0 -99.9 -99.9
1969     6   23.0    0.0       23.0 -99.9 -99.9
1969     7   33.0    0.0       33.0 -99.9 -99.9
1969     8   97.0    0.0       97.0 -99.9 -99.9
1969     9  295.0    0.0      295.0 -99.9 -99.9
1969    10  202.0    0.0      202.0 -99.9 -99.9
1969    11  475.0    0.0      475.0 -99.9 -99.9
1969    12  374.0  225.0      599.0 -99.9 -99.9

** 1970
1970     1  242.0   58.0      300.0 -99.9 -99.9
1970     2   77.0   10.0       87.0 -99.9 -99.9
1970     3  215.0   60.0      275.0 -99.9 -99.9
1970     3  306.0   90.0      396.0 -99.9 -99.9
1970     4  310.0   26.0      336.0 -99.9 -99.9
1970     5   59.0    0.0       59.0 -99.9 -99.9
1970     6   37.0    0.0       37.0 -99.9 -99.9
1970     7   26.0    0.0       26.0 -99.9 -99.9
1970     8   39.0    0.0       39.0 -99.9 -99.9
1970     9  125.0    0.0      125.0 -99.9 -99.9
1970    10  263.0    0.0      263.0 -99.9 -99.9
1970    11  259.0   59.0      318.0 -99.9 -99.9
1970    12   96.0  237.0      333.0 -99.9 -99.9

** 1971
1971     1  278.0   59.0      337.0 -99.9 -99.9
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                          WEATHER DATA
                           MYRA CREEK

YEAR MONTH   RAIN    SNOW TOTAL PCPN MAX T MIN T
               mm      cm         mm deg C deg C
---- ----- ------ ------ ---------- ----- -----



1971     2  207.0   46.0      253.0 -99.9 -99.9
1971     3  283.0  176.0      459.0 -99.9 -99.9
1971     4  153.0   63.0      216.0 -99.9 -99.9
1971     5   77.0    0.0       77.0 -99.9 -99.9
1971     6  136.0    0.0      136.0 -99.9 -99.9
1971     7   14.0    0.0       14.0 -99.9 -99.9
1971     8  113.0    0.0      113.0 -99.9 -99.9
1971     9  188.0    0.0      188.0 -99.9 -99.9
1971    10  334.0    0.0      334.0 -99.9 -99.9
1971    11  576.0    7.0      583.0 -99.9 -99.9
1971    12   33.0  344.0      377.0 -99.9 -99.9

**  1972
1972     1  126.0  124.0      250.0 -99.9 -99.9
1972     2  261.0  140.0      401.0 -99.9 -99.9
1972     3  422.0   53.0      475.0 -99.9 -99.9
1972     4  282.0  122.0      404.0 -99.9 -99.9
1972     5   34.0    0.0       34.0 -99.9 -99.9
1972     6   75.0    0.0       75.0 -99.9 -99.9
1972     8   82.0    0.0       82.0 -99.9 -99.9
1972     8   50.0    0.0       50.0 -99.9 -99.9
1972     9  241.0    0.0      241.0 -99.9 -99.9
1972    10   23.0    0.0       23.0 -99.9 -99.9
1972    11  322.0   11.0      333.0 -99.9 -99.9
1972    12  387.0   67.0      454.0 -99.9 -99.9

**  1973
1973     1  478.0  153.0      631.0 -99.9 -99.9
1973     2  176.0   32.0      208.0 -99.9 -99.9
1973     3  118.0   51.0      169.0 -99.9 -99.9
1973     4   34.0    0.0       34.0 -99.9 -99.9
1973     5  207.0    0.0      207.0 -99.9 -99.9
1973     6  105.0    0.0      105.0 -99.9 -99.9
1973     7   24.0    0.0       24.0 -99.9 -99.9
1973     8    7.0    0.0        7.0 -99.9 -99.9
1973     9   43.0    0.0       43.0 -99.9 -99.9
1973    10  366.0    0.0      366.0 -99.9 -99.9
1973    11  196.0  243.0      439.0 -99.9 -99.9
1973    12  596.0   26.0      622.0 -99.9 -99.9

**  1974
1974     1  495.0   80.0      575.0 -99.9 -99.9
1974     2  359.0   10.0      369.0 -99.9 -99.9
1974     3  680.0  118.0      798.0 -99.9 -99.9
1974     4  206.0    0.0      206.0 -99.9 -99.9
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Page No.      3
06/05/90
                          WEATHER DATA
                           MYRA CREEK

YEAR MONTH    RAIN    SNOW TOTAL PCPN MAX T MIN T
                mm      cm         mm deg C deg C
---- ----- ------ ------ ---------- ----- -----


1974     5  116.0     1.0       117.0 -99.9 -99.9
1974     6   52.0     0.0        52.0 -99.9 -99.9
1974     7   72.0     0.0        72.0 -99.9 -99.9
1974     8    4.0     0.0         4.0 -99.9 -99.9
1974     9   51.0     0.0        51.0 -99.9 -99.9
1974    10  162.0     0.0       162.0 -99.9 -99.9
1974    11  491.0    52.0       543.0 -99.9 -99.9
1974    12  520.0    17.0       537.0 -99.9 -99.9

**  1975
 1975    1  131.0   157.0       288.0 -99.9 -99.9
 1975    2   70.0   167.0       237.0 -99.9 -99.9
 1975    3  102.0    93.0       195.0 -99.9 -99.9
 1975    4   39.0    36.0        75.0 -99.9 -99.9
 1975    5   61.0     0.0        61.0 -99.9 -99.9
 1975    6   36.0     0.0        36.0 -99.9 -99.9
 1975    7    1.0     0.0         1.0 -99.9 -99.9
 1975    8  212.0     0.0       212.0 -99.9 -99.9
 1975    9    6.0     0.0         6.0 -99.9 -99.9
 1975   10  572.0    15.0       587.0 -99.9 -99.9
 1975   11 1128.0    90.0      1218.0 -99.9 -99.9
 1975   12  338.0   119.0       457.0 -99.9 -99.9

**  1976
 1976    1  188.0    85.0       273.0 -99.9 -99.9
 1976    2  215.0   139.0       354.0 -99.9 -99.9
 1976    3  184.0    47.0       231.0 -99.9 -99.9
 1976    4   81.0     0.0        81.0 -99.9 -99.9
 1976    5  110.0     0.0       110.0 -99.9 -99.9
 1976    6  187.0     0.0       187.0 -99.9 -99.9
 1976    7   78.0     0.0        78.0 -99.9 -99.9
 1976    8   74.0     0.0        74.0 -99.9 -99.9
 1976    9   65.0     0.0        65.0 -99.9 -99.9
 1976   10  236.0     0.0       236.0 -99.9 -99.9
 1976   11  224.0     0.0       224.0 -99.9 -99.9
 1976   12  304.0     1.0       305.0 -99.9 -99.9

**  1977
 1977    1   92.0    64.0       156.0 -99.9 -99.9
 1977    2  394.0    24.0       418.0 -99.9 -99.9
 1977    4  135.0     7.0       142.0 -99.9 -99.9
 1977    5  135.0     0.0       135.0 -99.9 -99.9
 1977    6   68.0     0.0        68.0 -99.9 -99.9
 1977    7   58.0     0.0        58.0 -99.9 -99.9
 1977    8   42.0     0.0        42.0 -99.9 -99.9
```

WEATHER DATA
MYRA CREEK

YEAR	MONTH	RAIN mm	SNOW cm	TOTAL PCPN mm	MAX T deg C	MIN T deg C
1977	9	150.0	0.0	150.0	-99.9	-99.9
1977	10	535.0	0.0	535.0	-99.9	-99.9
1977	11	607.0	23.0	630.0	-99.9	-99.9
1977	12	282.0	76.0	358.0	-99.9	-99.9
** 1978						
1978	1	82.0	195.0	277.0	-99.9	-99.9
1978	2	232.0	25.0	257.0	-99.9	-99.9
1978	3	340.0	0.0	340.0	-99.9	-99.9
1978	4	103.0	6.0	109.0	-99.9	-99.9
1978	5	122.0	0.0	122.0	-99.9	-99.9
1978	6	23.0	0.0	23.0	-99.9	-99.9
1978	7	21.0	0.0	21.0	-99.9	-99.9
1978	8	257.0	0.0	257.0	-99.9	-99.9
1978	9	283.0	0.0	283.0	-99.9	-99.9
1978	10	136.0	0.0	136.0	-99.9	-99.9
1978	11	264.0	12.0	276.0	-99.9	-99.9
1978	12	79.0	87.0	166.0	-99.9	-99.9
** 1979						
1979	1	65.0	49.0	114.0	-99.9	-99.9
1979	2	314.0	153.0	467.0	-99.9	-99.9
1979	3	273.0	58.0	331.0	-99.9	-99.9
1979	4	82.0	0.0	82.0	-99.9	-99.9
1979	5	90.0	0.0	90.0	-99.9	-99.9
1979	6	42.0	0.0	42.0	20.3	7.6
1979	7	123.0	0.0	123.0	24.1	11.0
1979	8	48.0	0.0	480.0	24.6	11.9
1979	9	372.0	0.0	372.0	18.5	8.8
1979	10	329.0	0.0	329.0	13.6	5.1
1979	11	181.0	0.0	181.0	4.0	0.2
1979	12	579.0	60.0	639.0	3.4	-0.3
** 1980						
1980	1	82.0	166.0	248.0	-1.1	-5.5
1980	2	301.0	8.0	309.0	3.4	-2.0
1980	3	93.0	54.0	147.0	6.8	-1.1
1980	4	227.0	10.0	237.0	12.2	1.2
1980	5	42.0	0.0	42.0	17.8	5.5
1980	6	87.0	0.0	87.0	18.7	8.1
1980	7	68.0	0.0	68.0	23.1	10.7
1980	9	200.0	0.0	200.0	19.2	8.5
1980	10	180.0	0.0	180.0	13.3	5.1
1980	11	451.0	0.0	451.0	6.3	2.0
1980	12	659.9	53.0	712.0	4.2	0.0

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                        WEATHER DATA
                         MYRA CREEK

YEAR MONTH    RAIN    SNOW TOTAL PCPN MAX T MIN T
                mm      cm         mm deg C deg C
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** 1981
 1981    1  344.0    3.0      347.0   5.0   1.0
 1981    2  426.0    0.0      426.0   4.5  -0.3
 1981    3  189.0    1.0      190.0  10.0   0.7
 1981    4  240.0   28.0      268.0  11.2   1.4
 1981    5  104.0    0.0      104.0  15.3   5.2
 1981    6  112.0    0.0      112.0  16.7   7.5
 1981    7   84.0    0.0       84.0  23.8  11.3
 1981    8   37.0    0.0       37.0  26.5  12.2
 1981    9  298.0    0.0      298.0  18.7   8.3
 1981   10  450.0    0.0      450.0  12.0   3.2
 1981   11  465.0    0.0      465.0   6.6   2.3
 1981   12  309.0  103.0      412.0   1.6  -2.2

** 1982
 1982    1  163.1  135.4      298.5   0.1  -4.0
 1982    2  371.0  134.4      505.4   3.0  -1.6
 1982    3   67.4   42.5      109.9   7.9  -2.2
 1982    4  129.2   64.0      193.2   9.7  -0.5
 1982    5   22.4    0.0       22.4  16.4   3.3
 1982    6   27.1    0.0       27.1  24.3   7.9
 1982    7   52.0    0.0       52.0  22.9  10.9
 1982    8   37.0    0.0       37.0  23.4  10.3
 1982    8   34.5    0.0       34.5  22.6  10.5
 1982    9   89.4    0.0       89.4  20.9   9.3
 1982   10  778.9    0.0      778.9  11.8   4.6
 1982   11  197.2   15.5      212.7   2.1  -1.6
 1982   12  461.7   31.0      492.7   1.5  -1.8

** 1983
 1983    1  511.0   18.5      529.5   3.3  -0.1
 1983    2  609.3   15.1      624.4   4.4   0.2
 1983    3  371.3    4.0      375.3   9.2   0.7
 1983    4   83.5    0.0       83.5  14.4   1.8
 1983    5   41.5    0.0       41.5  20.4   5.7
 1983    6  130.0    0.0      130.0  18.2   8.6
 1983    7   94.7    0.0       94.7  21.0   9.4
 1983    8   59.6    0.0       59.6  24.8  11.4
 1983    9   59.7    0.0       59.7  18.8   7.5
 1983   10  217.8    0.0      217.8  12.1   3.7
 1983   11  617.3    2.0      619.3   6.2   1.6
 1983   12   91.1  101.7      192.8  -1.0  -5.7
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WEATHER DATA
MYRA CREEK

YEAR	MONTH	RAIN mm	SNOW cm	TOTAL PCPN mm	MAX T deg C	MIN T deg C
** 1984						
1984	1	385.3	14.0	399.3	3.7	-1.7
1984	2	492.0	27.5	519.5	5.3	0.1
1984	3	164.2	23.4	187.6	9.5	1.1
1984	4	261.7	1.2	262.9	10.7	1.6
1984	5	192.7	0.0	192.7	13.3	3.9
1984	6	31.5	0.0	31.5	19.0	8.2
1984	7	8.8	0.0	8.8	25.4	11.0
1984	8	46.3	0.0	46.3	22.1	11.7
1984	9	95.0	0.0	95.0	17.8	6.8
1984	10	559.8	16.3	576.1	10.6	2.8
1984	11	261.2	78.6	339.8	3.2	-1.0
1984	12	159.2	60.9	220.1	-0.4	-4.5
** 1985						
1985	1	60.0	4.0	64.0	1.7	-2.7
1985	2	116.0	59.2	175.2	4.3	-2.2
1985	3	101.1	46.4	147.5	7.3	-1.9
1985	4	113.3	0.9	114.2	11.0	0.4
1985	5	90.3	1.9	92.2	17.3	4.1
1985	6	21.1	0.0	21.1	20.7	7.1
1985	7	32.3	0.0	32.3	28.6	11.4
1985	8	21.2	0.0	21.2	25.3	9.5
1985	9	76.9	0.0	76.9	19.5	6.2
1985	10	501.7	4.1	505.8	11.6	3.6
1985	11	385.2	24.3	409.5	4.5	0.3
1985	12	255.2	74.2	329.4	1.5	-3.4
** 1986						
1986	1	702.7	33.5	736.2	4.9	-1.2
1986	2	260.6	51.5	312.1	3.5	-3.8
1986	3	418.1	0.0	418.1	8.2	0.4
1986	4	85.0	3.2	88.2	10.9	1.9
1986	5	237.9	1.0	238.9	15.5	4.4
1986	6	89.2	0.0	89.2	20.5	9.0
1986	7	41.7	0.0	41.7	20.6	10.1
1986	8	4.0	0.0	4.0	29.7	13.2
1986	9	54.0	0.0	54.0	19.8	8.1
1986	10	176.0	0.0	176.0	16.4	4.5
1986	11	583.2	6.5	589.7	7.0	1.3
1986	12	355.1	34.9	390.0	2.6	-0.9
** 1987						
1987	1	509.0	24.4	533.4	3.3	-0.5
1987	2	321.3	15.5	336.8	6.3	0.3

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                              WEATHER DATA
                               MYRA CREEK

YEAR MONTH    RAIN    SNOW TOTAL PCPN MAX T MIN T
                mm      cm         mm deg C deg C
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1987     3  418.8    6.5      425.3   9.1   1.0
1987     4  262.7    0.0      262.7  12.3   2.4
1987     5  234.6    0.0      234.6  17.3   5.2
1987     6  184.0    0.0      184.0  22.5   9.1
1987     7   59.4    0.0       59.4  23.1   9.6
1987     8   18.3    0.0       18.3  26.4  11.2
1987     9   98.4    0.0       98.4  23.0   9.3
1987    10   83.8    0.0       83.8  14.7   4.9
1987    11  591.8    0.0      591.8   7.4   3.7
1987    12  400.9   36.5      437.4   1.6  -1.8

** 1988
1988     1  284.7   58.5      343.2   2.1  -1.6
1988     2  255.6    7.2      262.8   5.6  -0.6
1988     3  200.4   11.5      211.9   8.0   0.5
1988     4  197.7   17.7      215.4  13.4   2.4
1988     5  215.4    0.0      215.4  14.4   5.1
1988     6   80.0    0.0       80.0  18.5   7.1
1988     7   25.4    0.0       25.4  23.4   9.8
1988     8   29.1    0.0       29.1  24.7  11.4
1988     9  114.2    0.0      114.2  22.0   8.5
1988    10  246.4    0.0      246.4  14.0   6.1
1988    11  541.5   40.0      581.5   7.0   1.3
1988    12  144.2   57.0      201.2   4.7  -1.1

** 1989
1989     1  279.0   56.3      335.3   3.8  -4.1
1989     2   51.3   51.0      102.3   2.0  -7.6
1989     3  184.4   39.6      224.0   6.6  -1.9
1989     4  188.0   10.0      198.0  15.7   0.8
1989     5   62.5    0.0       62.5  18.1   4.3
1989     6   71.8    0.0       71.8  22.4   9.3
1989     7   41.7    0.0       41.7  22.2  11.0
1989     8   41.8    0.0       41.8  23.7  11.9
1989     9   17.6    0.0       17.6  23.4   8.8
1989    10  339.4    0.0      339.4  12.6   5.4
1989    11  236.5   13.3      249.8   6.5   1.8
1989    12    0.0    0.0        0.0   0.0   0.0
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Appendix D

XRF Analyses of Cores

APPENDIX D: XRF ANALYSES OF CORES

Table D-1

Major Element Composition and Major Element Ratios in Buttle Lake Cores (Analysis by XRF)

Sample Interval	Depth (cm)	Fe Wt. %	Ti Wt. %	Ca Wt. %	K Wt. %	Si Wt. %	Al Wt. %	Mg Wt. %	P Wt. %	Na Wt. %
CORE BUT 2										
0-0.5	0.25	7.24	0.46	1.86	0.91	17.91	8.09	1.88	0.135	0.47
0.5-1	0.75	10.03	0.50	2.03	0.83	18.76	8.00	2.01	0.113	0.57
1-1.5	1.25	10.69	0.43	1.73	0.79	18.76	7.77	1.77	0.105	0.50
1.5-2	1.75	6.97	0.46	1.66	1.30	20.90	9.43	2.03	0.096	0.62
2-3	2.5	4.36	0.29	0.43	3.44	22.21	12.31	1.91	0.044	0.34
3-4	3.5	4.43	0.31	0.49	3.35	21.82	12.37	1.95	0.048	0.35
4-5	4.5	5.12	0.36	0.80	2.88	21.49	11.69	2.03	0.061	0.36
5-6	5.5	5.77	0.37	0.89	2.66	20.89	11.31	1.98	0.061	0.40
6-8	7	4.79	0.33	0.47	3.20	21.48	11.92	1.74	0.057	0.31
8-10	9	5.92	0.28	0.34	3.32	20.24	12.92	2.16	0.048	0.29
10-12	11	7.24	0.52	1.66	1.83	20.95	10.47	2.27	0.092	0.62
12-14	13	8.53	0.74	3.11	0.56	21.71	8.13	2.88	0.113	0.70
16-18	17	8.60	0.77	3.21	0.53	21.61	7.97	2.93	0.113	0.73
22-26	24	8.73	0.74	3.22	0.51	21.69	7.89	2.89	0.109	0.70
38-42	40	8.55	0.76	3.12	0.50	21.12	7.79	2.88	0.109	0.72
50-54	52	8.80	0.78	3.33	0.48	21.70	7.89	3.04	0.105	0.72
CORE BUT 4										
0-0.5	0.25	7.25	0.49	1.87	0.82	20.60	8.27	1.86	0.126	0.90
0-0.5Rep	0.25	7.22	0.48	1.88	0.83	20.67	8.20	1.83	0.122	0.71
0.5-1	0.75	8.72	0.49	1.99	0.75	21.71	8.08	1.87	0.105	0.79
0.5-1Rep	0.75	8.71	0.48	2.00	0.77	21.75	7.95	1.86	0.096	0.78
1-1.5	1.25	8.79	0.48	1.96	0.77	22.20	8.01	1.80	0.096	0.75
1.5-2	1.75	7.71	0.47	1.77	1.13	22.25	8.57	1.87	0.087	0.76
2-3	2.5	4.53	0.34	0.46	3.16	23.07	11.28	1.78	0.048	0.37
3-4	3.5	4.35	0.32	0.34	3.39	22.98	11.58	1.91	0.044	0.34
4-5	4.5	4.55	0.34	0.49	3.18	22.80	11.45	1.94	0.044	0.36
5-6	5.5	4.67	0.32	0.44	3.19	22.58	11.30	1.91	0.048	0.36
6-8	7	4.82	0.34	0.51	3.03	22.52	11.33	1.93	0.048	0.38
8-10	9	5.05	0.32	0.41	2.96	22.18	10.95	1.76	0.048	0.39
12-14	13	4.75	0.35	0.46	3.16	22.22	11.20	1.64	0.052	0.35
16-18	17	7.11	0.34	0.49	2.96	20.33	11.26	2.18	0.052	0.32
18-22	20	7.63	0.34	0.50	2.88	19.53	11.19	2.36	0.052	0.37
26-30	28	7.17	0.51	1.96	0.75	21.48	7.94	1.98	0.105	0.78
34-38	36	6.75	0.53	2.25	0.72	22.89	8.06	2.12	0.100	0.86
38-42	40	6.71	0.57	2.37	0.66	23.14	8.09	2.18	0.100	0.88

Rep = repeated analysis of the same glass disc

Table D-2

Major Element Composition and Major Element Ratios in Buttle Lake Cores (Analysis by XRF)

Sample Interval	Depth (cm)	Fe Wt. %	Ti Wt. %	Ca Wt. %	K Wt. %	Si Wt. %	Al Wt. %	Mg Wt. %	P Wt. %	Na Wt. %
CORE BUT 5										
0-1	0.5	7.41	0.45	1.76	0.99	22.40	7.90	1.71	0.087	0.81
1-2	1.5	5.01	0.35	0.66	2.77	23.06	10.30	1.80	0.057	0.41
2-3	2.5	4.56	0.32	0.36	3.28	22.62	11.09	1.91	0.039	0.28
3-4	3.5	4.73	0.32	0.43	3.21	22.68	11.13	1.82	0.044	0.33
4-5	4.5	5.02	0.33	0.50	3.02	22.46	10.84	1.88	0.052	0.38
5-6	5.5	5.15	0.34	0.59	2.86	22.44	10.52	1.77	0.052	0.32
6-7	6.5	5.24	0.32	0.59	2.95	22.28	10.57	1.80	0.052	0.34
7-8	7.5	5.34	0.31	0.55	3.02	22.61	10.69	1.73	0.052	0.27
8-10	9	5.51	0.31	0.49	2.84	21.83	10.30	1.72	0.057	0.35
12-14	13	4.99	0.34	0.64	2.82	22.19	10.41	1.67	0.052	0.36
16-18	17	5.78	0.35	0.42	3.07	21.62	10.85	1.68	0.048	0.32
20-22	21	9.29	0.35	0.50	2.80	19.13	10.91	2.00	0.057	0.35
24-26	25	7.90	0.43	0.99	2.20	20.36	10.35	2.06	0.074	0.54
28-30	29	6.86	0.55	2.21	0.71	22.83	8.05	2.14	0.100	0.80
32-34	33	6.54	0.55	2.34	0.68	23.14	7.96	2.05	0.100	0.87
CORE BUT 6										
0-0.5	0.25	6.69	0.39	1.78	1.18	22.41	7.41	1.50	0.070	0.64
0.5-1	0.75	7.15	0.38	2.05	1.28	22.55	7.27	1.55	0.070	0.57
1-1.5	1.25	7.13	0.38	2.00	1.23	22.95	7.06	1.48	0.070	0.56
1.5-2	1.75	7.34	0.32	2.17	1.41	23.40	6.33	1.36	0.061	0.40
2-3	2.5	7.76	0.30	2.26	1.60	23.74	6.06	1.18	0.057	0.26
3-4	3.5	8.06	0.30	2.34	1.65	23.46	6.29	1.27	0.057	0.24
4-5	4.5	7.97	0.29	2.38	1.60	22.12	6.10	1.23	0.057	0.20
5-6	5.5	7.81	0.31	2.42	1.64	22.77	6.43	1.32	0.061	0.24
6-8	7	8.10	0.31	2.40	1.67	22.30	6.31	1.33	0.065	0.38
8-10	9	8.28	0.31	2.36	1.68	22.26	6.51	1.37	0.057	0.31
12-14	13	7.15	0.32	2.16	2.03	21.94	7.83	1.58	0.057	0.28
16-18	17	7.28	0.31	1.99	2.12	21.52	8.01	1.46	0.057	0.24
18-21	19.5	7.08	0.32	1.94	2.29	21.81	8.49	1.55	0.052	0.25
21-24	22.5	7.88	0.31	1.91	2.03	21.79	7.77	1.47	0.057	0.30
27-30	28.5	5.94	0.32	2.22	2.27	22.26	8.37	1.57	0.057	0.37

Table D-3

Major Element Composition and Major Element Ratios in Buttle Lake Cores (Analysis by XRF)

Sample Interval	Depth (cm)	Fe/Al Wt. Ratio	Si/Al Wt. Ratio	Ti/Al Wt. Ratio	Ca/Al Wt. Ratio	K/Al Wt. Ratio	Mg/Al Wt. Ratio	Na/Al Wt. Ratio
CORE BUT 2								
0-0.5	0.25	0.89	2.21	0.056	0.230	0.112	0.233	0.058
0.5-1	0.75	1.25	2.34	0.063	0.254	0.104	0.252	0.071
1-1.5	1.25	1.38	2.41	0.055	0.223	0.101	0.227	0.064
1.5-2	1.75	0.74	2.22	0.049	0.176	0.138	0.215	0.066
2-3	2.5	0.35	1.80	0.024	0.035	0.279	0.155	0.027
3-4	3.5	0.36	1.76	0.025	0.039	0.271	0.157	0.028
4-5	4.5	0.44	1.84	0.031	0.068	0.246	0.174	0.031
5-6	5.5	0.51	1.85	0.033	0.079	0.235	0.175	0.035
6-8	7	0.40	1.80	0.028	0.040	0.268	0.146	0.026
8-10	9	0.46	1.57	0.021	0.026	0.257	0.168	0.022
10-12	11	0.69	2.00	0.050	0.158	0.174	0.217	0.059
12-14	13	1.05	2.67	0.091	0.383	0.069	0.354	0.086
16-18	17	1.08	2.71	0.096	0.403	0.067	0.368	0.092
22-26	24	1.11	2.75	0.094	0.409	0.065	0.367	0.089
38-42	40	1.10	2.71	0.098	0.401	0.064	0.370	0.092
50-54	52	1.11	2.75	0.099	0.422	0.061	0.385	0.092
CORE BUT 4								
0-0.5	0.25	0.88	2.49	0.060	0.226	0.100	0.225	0.109
0-0.5Rep	0.25	0.88	2.52	0.059	0.229	0.101	0.224	0.086
0.5-1	0.75	1.08	2.69	0.061	0.247	0.093	0.231	0.098
0.5-1Rep	0.75	1.10	2.74	0.060	0.252	0.097	0.235	0.098
1-1.5	1.25	1.10	2.77	0.060	0.244	0.096	0.225	0.094
1.5-2	1.75	0.90	2.60	0.055	0.206	0.132	0.218	0.089
2-3	2.5	0.40	2.04	0.030	0.041	0.280	0.158	0.033
3-4	3.5	0.38	1.98	0.028	0.029	0.292	0.165	0.029
4-5	4.5	0.40	1.99	0.030	0.042	0.278	0.169	0.031
5-6	5.5	0.41	2.00	0.028	0.039	0.282	0.169	0.032
6-8	7	0.43	1.99	0.030	0.045	0.267	0.170	0.033
8-10	9	0.46	2.03	0.030	0.038	0.270	0.163	0.036
12-14	13	0.42	1.98	0.032	0.041	0.282	0.146	0.031
16-18	17	0.63	1.81	0.030	0.044	0.263	0.194	0.028
18-22	20	0.68	1.75	0.030	0.045	0.257	0.211	0.033
26-30	28	0.90	2.71	0.064	0.247	0.095	0.250	0.099
34-38	36	0.84	2.84	0.066	0.279	0.089	0.263	0.107
38-42	40	0.83	2.86	0.070	0.292	0.081	0.269	0.109

Rep = repeated analysis of the same glass disc

Table D-4

Major Element Composition and Major Element Ratios in Buttle Lake Cores (Analysis by XRF)

Sample Interval	Depth (cm)	Fe/Al Wt. Ratio	Si/Al Wt. Ratio	Ti/Al Wt. Ratio	Ca/Al Wt. Ratio	K/Al Wt. Ratio	Mg/Al Wt. Ratio	Na/Al Wt. Ratio
CORE BUT 5								
0-1	0.5	0.94	2.84	0.057	0.223	0.125	0.217	0.103
1-2	1.5	0.49	2.24	0.034	0.064	0.268	0.174	0.040
2-3	2.5	0.41	2.04	0.029	0.032	0.296	0.172	0.025
3-4	3.5	0.42	2.04	0.029	0.039	0.288	0.164	0.030
4-5	4.5	0.46	2.07	0.030	0.046	0.279	0.173	0.035
5-6	5.5	0.49	2.13	0.032	0.056	0.272	0.168	0.031
6-7	6.5	0.50	2.11	0.031	0.055	0.279	0.171	0.032
7-8	7.5	0.50	2.11	0.029	0.051	0.282	0.162	0.025
8-10	9	0.53	2.12	0.030	0.048	0.275	0.167	0.034
12-14	13	0.48	2.13	0.033	0.061	0.271	0.160	0.035
16-18	17	0.53	1.99	0.033	0.039	0.283	0.155	0.029
20-22	21	0.85	1.75	0.032	0.046	0.256	0.183	0.032
24-26	25	0.76	1.97	0.042	0.095	0.212	0.199	0.052
28-30	29	0.85	2.84	0.069	0.274	0.088	0.266	0.100
32-34	33	0.82	2.91	0.069	0.294	0.085	0.258	0.110
CORE BUT 6								
0-0.5	0.25	0.90	3.02	0.053	0.240	0.160	0.203	0.087
0.5-1	0.75	0.98	3.10	0.053	0.282	0.177	0.213	0.079
1-1.5	1.25	1.01	3.25	0.054	0.283	0.175	0.210	0.080
1.5-2	1.75	1.16	3.70	0.051	0.342	0.222	0.214	0.064
2-3	2.5	1.28	3.92	0.049	0.373	0.264	0.195	0.043
3-4	3.5	1.28	3.73	0.048	0.372	0.262	0.201	0.039
4-5	4.5	1.31	3.63	0.048	0.390	0.262	0.202	0.033
5-6	5.5	1.21	3.54	0.048	0.377	0.255	0.205	0.038
6-8	7	1.28	3.54	0.049	0.380	0.264	0.211	0.060
8-10	9	1.27	3.42	0.047	0.362	0.258	0.211	0.047
12-14	13	0.91	2.80	0.041	0.276	0.259	0.202	0.036
16-18	17	0.91	2.69	0.039	0.248	0.265	0.182	0.031
18-21	19.5	0.83	2.57	0.037	0.229	0.270	0.183	0.030
21-24	22.5	1.01	2.80	0.040	0.246	0.261	0.189	0.038
27-30	28.5	0.71	2.66	0.038	0.266	0.271	0.187	0.044

Table D-5

Minor Element Composition of Buttle Lake Cores, Determined by XRF Analysis

Sample Interval (cm)	Depth (cm)	Zr ppm	Sr ppm	Rb ppm	Pb ppm	Zn ppm	Cu ppm	Ni ppm	Co ppm	Mn ppm	V ppm	Cr ppm	Ba ppm
CORE BUT 2													
0-0.5	0.25	85	103	27	333	4262	1199	28	96	27147	254	70	2781
0.5-1	0.75	81	93	30	182	2403	913	7	57	10614	234	76	1860
1-1.5	1.25	76	80	26	186	3497	962	3	63	4268	211	70	1901
1.5-2	1.75	105	131	35	432	3722	1051	19	43	2126	265	68	4626
2-3	2.5	161	251	62	724	4166	1186	26	17	522	415	43	18229
3-4	3.5	146	251	54	783	4655	1381	22	13	440	433	52	21067
4-5	4.5	205	297	58	858	4872	2019	30	19	567	454	66	18315
5-6	5.5	204	289	52	882	4785	2159	29	19	716	447	69	17056
6-8	7	234	346	63	1138	5604	2188	26	13	428	499	47	21495
8-10	9	216	203	55	1281	6668	1778	17	10	493	417	50	13272
12-14	13	121	127	37	543	2192	1527	40	34	1955	301	96	3107
16-18	17	87	148	18	12	134	183	50	47	2598	284	131	545
22-26	24	91	151	18	13	147	195	57	46	2684	299	129	417
30-34	32	90	143	18	7	113	164	53	44	4992	268	130	315
38-42	40	85	140	16	9	103	170	50	45	2920	305	131	303
50-54	52	90	151	17	7	113	193	62	46	3088	292	131	304

Table D-6

Minor Element Composition of Buttle Lake Cores, Determined by XRF Analysis

Sample Interval (cm)	Depth (cm)	Zr ppm	Sr ppm	Rb ppm	Pb ppm	Zn ppm	Cu ppm	Ni ppm	Co ppm	Mn ppm	V ppm	Cr ppm	Ba ppm
CORE BUT 4													
0-0.5	0.25	88	119	30	209	2588	878	8	78	11552	221	63	1829
0.5-1	0.75	97	163	25	160	2283	792	13	64	6543	198	68	2352
1-1.5	1.25	93	140	27	138	1863	643	2	60	3083	216	62	2600
1.5-2	1.75	102	169	33	207	2145	565	11	37	1408	233	48	5327
2-3	2.5	223	366	67	715	4085	1122	35	16	243	471	52	21178
3-4	3.5	236	376	75	640	4345	1089	32	14	163	496	56	23996
4-5	4.5	244	377	68	667	5136	1159	33	12	219	492	62	23787
5-6	5.5	254	414	67	884	6039	1331	32	16	162	500	55	25458
6-8	7	244	416	66	739	5615	1484	34	17	215	526	55	25434
8-10	9	247	471	62	894	6152	1886	31	11	169	542	53	27120
10-12	11	252	439	63	1066	6561	1831	32	17	169	544	40	27597
16-18	17	211	312	53	1395	8520	2160	35	17	556	417	52	17281
18-22	20	205	263	50	1423	8346	2195	31	18	751	402	52	14870
26-30	28	90	159	25	77	509	239	19	36	2108	237	71	1621
38-42	40	91	171	25	34	236	150	21	36	1955	216	72	845
42-46	44	94	173	25	9	115	127	27	36	1974	223	76	511

Table D-7

Minor Element Composition of Buttle Lake Cores, Determined by XRF Analysis

Sample Interval (cm)	Depth (cm)	Zr ppm	Sr ppm	Rb ppm	Pb ppm	Zn ppm	Cu ppm	Ni ppm	Co ppm	Mn ppm	V ppm	Cr ppm	Ba ppm
CORE BUT 5													
0-1	0.5	108	202	25	231	2515	798	16	35	2679	224	66	4798
1-2	1.5	219	371	57	632	4444	1025	29	16	588	436	57	20797
2-3	2.5	249	400	70	741	5292	1179	30	14	161	478	56	23761
3-4	3.5	266	419	64	772	5668	1214	31	10	147	477	56	25693
4-5	4.5	262	443	63	726	5547	1302	31	15	168	498	57	26254
5-6	5.5	253	461	60	761	6256	1387	30	14	183	490	54	27161
6-7	6.5	259	518	63	853	6693	1488	29	15	145	519	53	28442
7-8	7.5	254	540	62	891	6463	1565	33	19	145	542	49	29820
8-10	9	255	540	61	991	7118	1795	29	17	133	527	50	29781
12-14	13	247	482	57	985	6502	1428	28	14	204	528	38	29000
16-18	17	222	416	58	1387	9156	2159	31	13	198	489	47	24235
20-22	21	190	228	47	1304	10104	1826	26	17	550	341	54	11860
24-26	25	150	189	37	1251	7877	2752	41	28	792	321	81	8492
28-30	29	90	162	24	29	241	130	22	31	1357	232	77	1077
32-34	33	88	168	22	12	153	116	21	28	1452	219	73	737

Table D-8

Minor Element Composition of Buttle Lake Cores, Determined by XRF Analysis

Sample Interval (cm)	Depth (cm)	Zr ppm	Sr ppm	Rb ppm	Pb ppm	Zn ppm	Cu ppm	Ni ppm	Co ppm	Mn ppm	V ppm	Cr ppm	Ba ppm
CORE BUT 6													
0-0.5	0.25	141	299	30	386	3351	777	16	31	1164	292	55	12163
0.5-1	0.75	164	354	29	418	3572	796	20	25	914	324	52	15496
1-1.5	1.25	171	383	28	385	3344	732	17	28	737	335	48	17279
1.5-2	1.75	237	544	32	403	3309	608	20	22	459	424	51	26686
2-3	2.5	264	663	35	452	3691	621	30	17	273	485	42	32287
3-4	3.5	266	657	38	472	3850	644	28	18	294	471	43	31827
4-5	4.5	281	677	37	482	3979	631	25	13	286	510	39	34642
5-6	5.5	271	732	38	579	5066	754	31	15	283	528	34	35528
6-8	7	282	746	38	651	5105	785	29	21	280	551	28	37772
8-10	9	283	741	38	697	4794	822	31	21	302	549	27	35821
12-14	13	278	672	44	716	4256	859	30	23	343	514	34	31596
16-18	17	293	684	47	725	4595	853	33	18	319	559	27	34656
18-21	19.5	287	600	49	711	4156	898	29	18	332	520	35	29925
21-24	22.5	282	641	44	752	4241	929	31	16	353	529	27	32100
27-30	28.5	301	764	53	667	4128	865	34	15	264	571	40	33741
33-36	34.5	289	647	45	543	4678	744	38	15	334	508	58	30893

CNS Analyses of Cores

APPENDIX E: CNS ANALYSES OF CORES

Table E-1

Carbonate, Organic Carbon, Nitrogen and Sulphur Data for Buttle Lake Cores

Sample Interval (cm)	Depth (cm)	Carbonate-C Wt. %	$CaCO_3$ Wt. %	Total C Wt. %	Organic C Wt. %	Total N Wt. %	Org. C/N	S Wt. %
CORE BUT 2								
0-0.5	0.25	0.14	1.17	7.55	7.41	0.48	15.4	0.33
0.5-1	0.75	0.05	0.42	6.35	6.30	0.40	15.9	0.19
1-1.5	1.25	0.03	0.25	6.56	6.53	0.44	14.9	0.33
1.5-2	1.75	0.01	0.08	5.03	5.02	0.31	16.4	0.52
2-3	2.5	0.01	0.08	1.44	1.43	0.08	17.1	1.83
3-4	3.5	0.01	0.05	1.32	1.31	0.07	17.7	2.02
4-5	4.5	0.01	0.08	1.88	1.88	0.10	18.0	1.74
5-6	5.5	0.02	0.17	2.56	2.54	0.14	18.3	1.91
6-8	7	0.02	0.17	1.53	1.51	0.08	18.7	2.32
8-10	9	0.04	0.33	0.87	0.83	0.05	15.6	5.40
12-14	13	0.02	0.17	3.86	3.84	0.20	18.9	1.63
16-18	17	0.01	0.04	4.83	4.83	0.25	19.0	0.08
22-26	24	0.02	0.17	4.82	4.80	0.26	18.5	0.08
30-34	32	0.01	0.09	4.46	4.45	0.23	19.2	0.05
38-42	40	0.02	0.17	5.06	5.04	0.26	19.4	0.06
50-54	52	0.04	0.33	4.80	4.76	0.24	20.1	0.09
CORE BUT 4								
0-0.5	0.25	0.05	0.42	6.76	6.71	0.40	16.6	0.36
0.5-1	0.75	0.03	0.25	5.07	5.04	0.31	16.5	0.36
1-1.5	1.25	0.02	0.17	4.86	4.84	0.29	16.9	0.36
1.5-2	1.75	0.01	0.08	4.60	4.59	0.25	18.4	0.62
2-3	2.5	0.05	0.42	1.01	0.96	0.06	16.3	2.86
3-4	3.5	0.04	0.33	0.52	0.48	0.04	13.7	3.33
4-5	4.5	0.05	0.42	0.74	0.69	0.04	16.4	3.22
5-6	5.5	0.04	0.33	0.71	0.67	0.04	18.5	3.41
6-8	7	0.04	0.33	0.87	0.83	0.04	18.8	2.94
8-10	9	0.04	0.33	1.04	1.00	0.06	17.8	3.36
12-14	13	0.08	0.67	0.97	0.89	0.04	21.2	3.90
16-18	17	0.15	1.25	0.65	0.50	0.03	18.0	7.30
18-22	20	0.17	1.42	0.67	0.50	0.03	19.3	8.16
26-30	28	0.02	0.17	7.54	7.52	0.32	23.9	0.39
34-38	36	0.01	0.08	5.94	5.93	0.30	19.6	0.18
38-42	40	0.01	0.05	5.33	5.32	0.26	20.9	0.06

Table E-2

Carbonate, Organic Carbon, Nitrogen and Sulphur Data for Buttle Lake Cores

Sample Interval (cm)	Depth (cm)	Carbonate-C Wt. %	$CaCO_3$ Wt. %	Total C Wt. %	Organic C Wt. %	Total N Wt. %	Org. C/N	S Wt. %
CORE BUT 5								
0-1	0.5	0.01	0.08	5.12	5.11	0.26	19.7	1.18
1-2	1.5	0.02	0.17	1.75	1.73	0.09	19.9	3.17
2-3	2.5	0.04	0.33	0.58	0.54	0.03	15.9	3.73
3-4	3.5	0.05	0.42	0.60	0.55	0.03	17.8	3.59
4-5	4.5	0.05	0.42	0.77	0.72	0.04	19.4	3.49
5-6	5.5	0.08	0.67	0.87	0.79	0.04	19.7	3.98
6-7	6.5	0.13	1.08	0.64	0.51	0.03	18.3	4.14
7-8	7.5	0.13	1.08	0.69	0.56	0.04	15.2	4.11
8-10	9	0.08	0.67	0.97	0.89	0.04	20.7	4.61
12-14	13	0.12	1.00	1.29	1.17	0.05	24.5	3.96
16-18	17	0.11	0.92	0.49	0.38	0.02	16.5	5.56
20-22	21	0.21	1.75	0.69	0.48	0.03	14.9	10.74
24-26	25	0.07	0.58	2.40	2.33	0.11	20.8	6.21
28-30	29	0.02	0.17	6.09	6.07	0.31	19.5	0.23
32-34	33	0.02	0.17	6.39	6.37	0.31	20.7	0.12
CORE BUT 6								
0-0.5	0.25	0.14	1.17	5.40	5.26	0.21	24.6	3.92
0.5-1	0.75	0.30	2.50	5.07	4.77	0.18	26.7	5.05
1-1.5	1.25	0.30	2.50	4.19	3.89	0.15	26.5	5.39
1.5-2	1.75	0.54	4.50	2.28	1.74	0.07	26.7	7.47
2-3	2.5	0.68	5.67	0.95	0.27	0.01	22.1	9.44
3-4	3.5	0.72	6.00	0.89	0.17	0.01	24.6	9.71
4-5	4.5	0.73	6.08	1.00	0.27	0.01	24.8	9.83
5-6	5.5	0.73	6.08	0.93	0.20	0.01	25.3	9.91
6-8	7	0.74	6.17	0.93	0.19	0.01	16.9	10.23
8-10	9	0.72	6.00	0.89	0.17	0.01	16.5	10.12
12-14	13	0.65	5.42	1.05	0.40	0.02	23.5	8.31
16-18	17	0.64	5.33	0.78	0.14	0.01	12.0	8.79
18-21	20	0.61	5.08	0.72	0.11	0.01	15.7	8.52
21-24	23	0.60	5.00	0.67	0.07	0.01	10.6	9.27
27-30	29	0.68	5.67	0.77	0.09	0.01	15.3	6.78
33-36	35	0.83	6.92	0.94	0.11	0.01	14.1	8.82

Appendix F

Mineralogy by X-Ray Diffractometry

Rescan

APPENDIX F: MINERALOGY BY X-RAY DIFFRACTOMETRY

Buttle Lake Sediments

The table below lists the minerals identified in each sample. the minerals are listed in decreasing abundance which is a function of the overall intensities of the most prominent peaks.

Sample Identification	Minerals Present	Sample Identification	Minerals Present
BUT 2 0.5-1	Quartz Feldspar (Albite) Clay (Chlorite) Clay (Muscovite), trace amounts	BUT 5 0-1	Quartz Feldspar (Albite) Clay (Chlorite) Clay (Muscovite), minor amounts Pyrite, trace amounts
BUT 2 8-10	Quartz Pyrite Clay (Muscovite) Clay (Chlorite) Feldspar (Albite)	BUT 5 32-34	Quartz Feldspar (Albite) Clay (Chlorite) Clay (Muscovite), trace amounts Calcite, trace amounts
BUT 4 2-3	Quartz Clay (Muscovite) Clay (Chlorite) Feldspar (Albite) Pyrite, minor amounts	BUT 6 0-0.5	Quartz Feldspar (Albite) Clay (Chlorite) Pyrite Clay (Muscovite) Calcite, trace amounts
BUT 4 16-18	Quartz Pyrite Clay (Muscovite) Clay (Chlorite) Feldspar (Albite)	BUT 6 12-14	Quartz Clay (Muscovite) Clay (Chlorite) Calcite Pyrite Feldspar (Albite)

All of the tailings samples (BUT 2 8-10 cm, BUT 4 16-18 cm, BUT 6 12-14 cm) contain abundant quartz, clays, pyrite, and feldspar. It should be noted that the abundance of feldspar is less in these samples than in the sample of natural sediments and mine tailings (BUT 2 0.5-1 cm, BUT 4 2-3 cm, BUT 5 0-1 cm, BUT 6 0-0.5 cm). The natural sediments mixed with tailings also contained quartz, feldspar, clays, and pyrite. In these samples the abundance of clay minerals and pyrite was less than those samples of the tailings. The sample of natural sediment (pre-mining) contained abundant quartz, feldspar, and the clay mineral chlorite along with trace amounts of calcite. Pyrite was absent. It should also be noted that the only other two samples that were found to contain calcite were BUT 6 0-0.5 cm and BUT 6 12-14 cm.

Appendix G

Metal Analyses in Pore Water

Rescan

APPENDIX G: METAL ANALYSES IN PORE WATER

Table G-1

Dissolved Metal Concentrations in Buttle Lake Pore Waters (ppb)

Horizon (cm)	Mid Depth (cm)	Zn (ppb)	Fe (ppb)	Mn (ppb)	Cd (ppb)	Cu (ppb)	Pb (ppb)
CORE BUT 2							
Supernat.	-0.25	62.6	8.8	246	0.47	2.6	0.32
0-0.5	0.25	120	68.8	2400	1.03	15	1.9
0.5-1.0	0.75	63.8	81.6	3830	0.55	5.6	0.31
1.0-1.5	1.25	102	2550	3470	0.1	5	0.69
1.5-2.0	1.75	115	850	2620	0.045	3.2	3.0
2-3	2.5	85.2	4400	4300	0.013	3.2	5.3
3-4	3.5	133	7850	3620	0.043	2.9	5.5
4-5	4.5	138	10000	4420	0.031	1.7	4.0
5-6	5.5	132	14500	5490	0.025	2.3	3.5
6-8*	7	462	28200	6230	0.27	135	137
8-10*	9	449	34000	8400	0.217	281	262
12-14	13	12.9	30900	11700	0.014	8.4	6.0
16-18	17	9.5	26400	11900	0.014	2.8	0.58
22-26	24	4.2	35100	16300	0.011	4.8	0.76
30-34	32	4.4	40500	16600	0.021	2.8	0.23
38-42	40	2.2	45900	16300	0.008	1.8	0.12
50-54	52	2.4	52400	15900	0.028	5.2	0.21

* Humic acid precipitate

Table G-2

Dissolved Metal Concentrations in Buttle Lake Pore Waters (μmol/L and nmol/L)

Horizon (cm)	Mid Depth (cm)	Zn μmol/L	Fe μmol/L	Mn μmol/L	Cd nmol/L	Cu μmol/L	Pb μmol/L
CORE BUT 2							
Supernat.	-0.25	0.96	0.16	4.48	4.2	0.041	0.0015
0-0.5	0.25	1.84	1.23	43.7	9.2	0.24	0.0092
0.5-1.0	0.75	0.98	1.46	69.7	4.9	0.088	0.0015
1.0-1.5	1.25	1.56	45.7	63.2	0.89	0.079	0.0033
1.5-2.0	1.75	1.76	15.2	47.7	0.40	0.050	0.014
2-3	2.5	1.30	78.8	78.3	0.12	0.050	0.026
3-4	3.5	2.03	141	65.9	0.38	0.046	0.027
4-5	4.5	2.11	179	80.5	0.28	0.027	0.019
5-6	5.5	2.02	260	99.9	0.22	0.036	0.017
6-8*	7	7.07	505	113	2.40	2.12	0.661
8-10*	9	6.87	609	153	1.93	4.42	1.265
12-14	13	0.20	553	213	0.12	0.13	0.029
16-18	17	0.15	473	217	0.12	0.044	0.0028
22-26	24	0.064	628	297	0.098	0.076	0.0037
30-34	32	0.067	725	302	0.19	0.044	0.0011
38-42	40	0.034	822	297	0.071	0.028	0.0006
50-54	52	0.037	938	289	0.25	0.082	0.0010

* Humic acid precipitate

Table G-3

Dissolved Metal Concentrations in Buttle Lake Pore Waters (ppb)

Horizon (cm)	Mid Depth (cm)	Zn (ppb)	Fe (ppb)	Mn (ppb)	Cd (ppb)	Cu (ppb)	Pb (ppb)
CORE BUT 4							
Supernat.	-0.25	133	11	16.8	0.48	2.2	0.67
0-0.5	0.25	220	230	521	0.88	16.7	3.9
0.5-1.0	0.75	231	71	1680	0.73	8.1	1.2
1.0-1.5	1.25	300	479	1670	0.52	6.8	1.6
1.5-2.0	1.75	263	823	1320	0.39	3.9	2.2
2-3	2.5	287	2680	1690	0.32	5.9	5.3
3-4	3.5	390	4220	1440	0.21	15.7	16.4
4-5	4.5	348	6600	1140	0.13	6.5	8.4
5-6	5.5	357	15800	1490	0.019	5	4.6
6-8*	7	1568	30100	1720	0.74	206	149
8-10*	9	455	32400	2030	0.049	6.8	6.6
12-14	13	176	40000	2350	0.053	15.1	5.8
16-18	17	338	56100	4710	0.31	84.6	38
18-22	20	976	57200	4530	1.1	323	153
26-30	28	35.2	47200	8380	0.13	7.4	5.9
34-38	36	9.4	28800	8800	0.084	5.3	1.9
42-46	44	8.2	33900	9950	0.05	6.1	0.59

* Humic acid precipitate

Table G-4

Dissolved Metal Concentrations in Buttle Lake Pore Waters (µmol/L and nmol/L)

Horizon (cm)	Mid Depth (cm)	Zn µmol/L	Fe µmol/L	Mn µmol/L	Cd nmol/L	Cu µmol/L	Pb µmol/L
CORE BUT 4							
Supernat.	-0.25	2.03	0.20	0.306	4.3	0.03	0.003
0-0.5	0.25	3.37	4.12	9.48	7.8	0.26	0.019
0.5-1.0	0.75	3.53	1.27	30.6	6.5	0.13	0.006
1.0-1.5	1.25	4.59	8.58	30.4	4.6	0.11	0.008
1.5-2.0	1.75	4.02	14.7	24.0	3.5	0.06	0.011
2-3	2.5	4.39	48.0	30.8	2.8	0.09	0.026
3-4	3.5	5.97	75.6	62.2	1.9	0.25	0.079
4-5	4.5	5.32	118	20.7	1.2	0.10	0.041
5-6	5.5	5.46	283	27.1	0.17	0.08	0.022
6-8*	7	24.0	539	31.3	6.6	3.24	0.72
8-10*	9	6.96	580	36.9	0.44	0.11	0.032
12-14	13	2.69	716	42.8	0.47	0.24	0.028
16-18	17	5.17	1004	85.7	2.8	1.33	0.18
18-22	20	14.9	1024	82.5	9.8	5.08	0.74
26-30	28	0.54	845	153	1.2	0.12	0.028
34-38	36	0.14	516	160	0.75	0.083	0.009
42-46	44	0.13	607	181	0.44	0.096	0.003

* Humic acid precipitate

Table G-5

Dissolved Metal Concentrations in Buttle Lake Pore Waters (ppb)

Horizon (cm)	Mid Depth (cm)	Zn (ppb)	Fe (ppb)	Mn (ppb)	Cd (ppb)	Cu (ppb)	Pb (ppb)
CORE BUT 5							
Supernat.	-0.5	63.3	19.8	155	0.19	2.8	1.5
0-1	0.5	108	1400	3050	0.06	5.4	2.8
1-2	1.5	116	1710	3000	0.048	7.9	6.5
2-3	2.5	404	8040	1920	0.099	1.1	1.5
4-Mar	3.5	524	8420	1330	0.3	0.62	0.51
4-5*	4.5	827	13900	1220	1.04	87.8	73.3
5-6	5.5	343	14900	1240	0.24	0.79	1.6
6-7	6.5	432	17000	1320	0.29	0.71	2.7
7-8	7.5	332	17200	1060	0.21	0.76	1.2
8-10	9	900	48600	1220	0.037	1.2	2.3
12-14	13	176	54900	1200	0.035	25.3	11.2
16-18	17	564	71200	1590	0.18	115	41.9
20-22	21	308	76200	2420	0.23	77.6	34.8
24-26*	25	244	60200	4160	0.83	137	151
28-30	29	7.6	38600	3680	0.052	5.9	3.1
32-34	33	2.9	42600	4930	0.018	2.4	0.78

* Humic acid precipitate

Table G-6

Dissolved Metal Concentrations in Buttle Lake Pore Waters (μmol/L and nmol/L)

Horizon (cm)	Mid Depth (cm)	Zn μmol/L	Fe μmol/L	Mn μmol/L	Cd nmol/L	Cu μmol/L	Pb μmol/L
CORE BUT 5							
Supernat.	-0.5	63.3	19.8	155	0.19	2.8	1.5
0-1	0.5	108	1400	3050	0.06	5.4	2.8
1-2	1.5	116	17100	3000	0.048	7.9	6.5
2-3	2.5	404	8040	1920	0.099	1.1	1.5
4-Mar	3.5	524	8420	1330	0.3	0.62	0.51
4-5*	4.5	827	13900	1220	1.04	87.8	73.3
5-6	5.5	348	14900	1240	0.24	0.79	1.6
6-7	6.5	432	17000	1320	0.29	0.71	2.7
7-8	7.5	332	17200	1060	0.21	0.76	1.2
8-10	9	900	48600	1220	0.037	1.2	2.3
12-14	13	176	54900	1200	0.035	25.3	11.2
16-18	17	564	71200	1590	0.18	115	41.9
20-22	21	308	76200	2420	0.23	77.6	34.8
24-26*	25	244	60200	4160	0.83	137	151
28-30	29	7.6	38600	3680	0.052	5.9	3.1
32-34	33	2.9	42600	4930	0.018	2.4	0.78

* Humic acid precipitate

Table G-7

Dissolved Metal Concentrations in Buttle Lake Pore Waters (ppb)

Horizon (cm)	Mid Depth (cm)	Zn (ppb)	Fe (ppb)	Mn (ppb)	Cd (ppb)	Cu (ppb)	Pb (ppb)
CORE BUT 6							
Supernat.	-0.25	64.8	53.5	152	0.062	2.9	2.7
0-0.5	0.25	19.8	512	2260	0.013	2.2	1.8
0.5-1.0	0.75	13	263	1840	0.009	3.8	1.9
1.0-1.5	1.25	21	2850	1260	0.063	12.7	N.S.
1.5-2.0	1.75	12.6	1150	1060	0.01	2	1.1
2-3	2.5	23.4	165	376	0.017	3	4.2
3-4	3.5	7	29.1	156	N.S.	2	3.8
4-5	4.5	12.6	38.2	102	0.002	1.3	5
5-6	5.5	10.2	49.1	178	0.002	2	3.7
6-8	7	15.4	38.9	102	0.019	5.4	8.1
8-10	9	22.8	67.7	84	0.011	6.4	11.2
12-14	13	54	226	155	0.041	11.7	16.6
16-18	17	7.8	12.5	83	0.005	1.6	3.4
18-21	19.5	10.9	16.5	51	0.006	2.2	4.3
21-24	22.5	25.4	52.6	37.1	0.01	5.2	9.2
27-30	28.5	390	1250	25.1	0.39	74.3	88.5
33-36	34.5	308	690	12.1	0.39	29.2	42.4

* Humic acid precipitate

Table G-8

Dissolved Metal Concentrations in Buttle Lake Pore Waters (μmol/L and nmol/L)

Horizon (cm)	Mid Depth (cm)	Zn μmol/L	Fe μmol/L	Mn μmol/L	Cd nmol/L	Cu μmol/L	Pb μmol/L
CORE BUT 6							
Supernat.	-0.25	0.99	0.96	2.77	0.55	0.046	0.013
0-0.5	0.25	0.30	9.17	41.1	0.12	0.035	0.009
0.5-1.0	0.75	0.20	4.71	33.5	0.08	0.060	0.009
1.0-1.5	1.25	0.32	51.0	22.9	0.56	0.200	N.S.
1.5-2.0	1.75	0.19	20.6	19.3	0.09	0.031	0.005
2-3	2.5	0.36	2.95	6.84	0.15	0.047	0.020
3-4	3.5	0.11	0.52	2.84	N.S.	0.031	0.018
4-5	4.5	0.19	0.68	1.86	0.02	0.020	0.024
5-6	5.5	0.16	0.88	3.24	0.02	0.031	0.018
6-8	7	0.24	0.70	1.86	0.17	0.085	0.039
8-10	9	0.35	1.21	1.53	0.10	0.101	0.054
12-14	13	0.83	4.05	2.82	0.36	0.184	0.080
16-18	17	0.12	0.22	1.51	0.04	0.025	0.016
18-21	19.5	0.17	0.30	0.93	0.05	0.035	0.021
21-24	22.5	0.39	0.94	0.68	0.09	0.082	0.044
27-30	28.5	5.97	22.4	0.46	3.47	1.169	0.427
33-36	34.5	4.71	12.4	0.22	3.47	0.460	0.205

* Humic acid precipitate